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Research Paper

Library Sound Level Meter

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ABSTRACT: *Most libraries, whilst ensuring that the necessary facilities are available to its users, also seek to provide an atmosphere conducive enough for research, study, and assimilation. However, noiseis a major hindrance to achieving such conducive arrangements in our libraries. Therefore, measures need to be taken to help eliminate this problem. This project is aimed at designing and implementing a sound level meter, with audio announcement for maintaining peace and quietness in a library. A sound level meter is simply a device with audio-frequency sensing capabilities that is controlled, essentially, by a microcontroller, which measures, compares, and triggers the appropriate action (makes an audio announcement) to reduce noise level once the critical sound level has been exceeded. The sound level meter consists of a Condenser microphone (to convert the sound into electrical signal), Pre-Amplifier (amplifies the electrical signal), Microcontroller (with internal ADC feature – to capture and compare the input signal with a critical value), Play and Record Chip (to play a pre-recorded message, alerting library users of increasing sound level), Power Amplifier (amplifies the output of the play and record chip), and LCD display (displays the sound levels). The Sound Level Meter measures sound level in decibels and can be used for activities such as environmental noise studies, sound level comparisons, investigating room acoustics, sound isolation modeling, sound propagation modeling etc. It can be applied in libraries, hospitals, laboratories, lecture rooms, meditation rooms amongst many others.*
Keywords: *Amplifier, LCD Display, Library, Microcontroller, Microphone, and Sound Level Meter.*

I. INTRODUCTION

I.1 Project Objective

This project is aimed at designing and implementing all the modules in a sound level meter, with audio announcement for maintaining peace and quietness in a library. These modules include:

- Building a pre-amplifier stage.
- Writing and installing in microcontroller, a microprogram using MikroC programming language, to enable it to be interfaced with an LCD display for sound level, compare input sound signals to a critical level and send out a signal when it is above the critical level.
- Designing a voice processor that will play a pre-recorded message to the users of the library whenever the noise level is high.
- Building a power amplifier stage.

I.2 The Library

A library is an organized collection of information resources made accessible to a defined community for reference or borrowing. It provides physical or digital access to material, and may be a physical building or room, or a virtual space, or both. A library's collection can include books, periodicals, newspapers, manuscripts, films, maps, prints, documents, microform, CDs, cassettes, videotapes, DVDs, Blu-ray Discs,e-books, audiobooks, databases, and other formats. Libraries range in size from a few shelves of books to several million items.[1]

Most libraries whilst ensuring that the necessary facilities are available to its users, also seek to provide an atmosphere conducive enough for research, study and assimilation. However, noiseis a major hindrance to achieving such conducive arrangements in modern libraries as it has become a rampart issue of note over time.Therefore, measures need to be taken to help eliminate the problem of noise in our libraries so as to promote ideal conditions in libraries today.

I.3 Noise in the Library

Noise refers to any unwanted sound or unwanted random additions to a signal as seen in most electronic designs and signal noise is heard as acoustic noise if the signal is converted into sound (e.g., played through a loudspeaker). High noise levels can block, distort, change or interfere with the meaning of a message in human, animal and electronic communication. "Signal-to-noise ratio" is sometimes used to refer to the ratio of useful to irrelevant information in an exchange.Noise affects the mind and changes emotions and behavior in many ways. It interferes with our communication and arouses our sense of fear. It is overly arousing and presents too high a level of stimulation.[2] The effects of noise on people in the library are as follows:

- **Health Effect**: Health is not merely an absence of disease and infirmity.Health is a state of complete physical, mental and social well-being. Hardly a day passes without being subjected to some intruding noise whether inside of the library or outside of it. Health is prejudiced by interference with peace of mind, privacy, work or pleasure. Continued research is being performed to relate psychological and physiological effect of noise on man.
- **Performance Effect**: It is likely that any new sound or change in an existing sound may result in at least momentary distraction and this may impair a person's ability to perform some tasks. Reading in the libraries is most prone to disturbances since it has a little margin for error, requires interaction with more than one source or sensing channel.

Typically, the impairment in the libraries in the presence of noise takes the form of signals (points) being missed, increased error in response (assimilation) and prolonged assimilation time. High noise levels can contribute to cardiovascular effects in humans, a rise in blood pressure, and an increase in stress and vasoconstriction, and an increased incidence of coronary artery disease.

I.4 Sound Level Meter

Sound level is not a measure of loudness, as loudness is a subjective factor and depends on the characteristics of the ear of the listener. In the early 1970s, as concern about noisepollution increased, accurate, versatile, portable noise-measuring instruments were developed. Noise control in a library is of utmost importance, since the basic aim of a library is to provide a conducive environment for its users to conduct research and study. This project looks to eliminate the presence of an administrative presence designated the role of noise control as in the past. Therefore, the essence of having an automated sound level system is to reduce the possibility that the personnel-in-charge might cause some kind of noise whilst trying to alert library users to their increasing sound level.

Consequently, a sound level meter is simply a device with audio-frequency sensing capabilities that is controlled essentially by a microcontroller in turn measuring, comparing and regulating audio signals all in a bid to reduce noise level in a library as well as maintain a stable audio frequency throughout the library environment. The Sound Level Meter measures sound level in decibels (dB; a logarithmic unit used to measure the sound intensity) and it can be used for activities such as environmental noise studies, sound level comparisons, investigating room acoustics, sound isolation modeling and sound propagation modeling amongst many others.[3]

A typical meter consists of a microphone for picking up the sound and converting it into an electrical signal, followed by electronic circuitry for operating on this signal so that the desired characteristics can be measured. Sound meters are usually fitted with a filter whose response to frequency is almost like that of the human ear. Sound level meters are usually digital these days, although there are some analog units of older designs still available. With the lower cost units for simple measurements, many find the analog sound level meter to be easier to use: you can see by eye the variations in level and average it out yourself. More expensive instruments tend to be "integrating", which does this job for you. Digital displays also allow a wider span to be shown whilst still giving the necessary decibel resolution therefore it is easier (and cheaper) to monitor sound level digitally.

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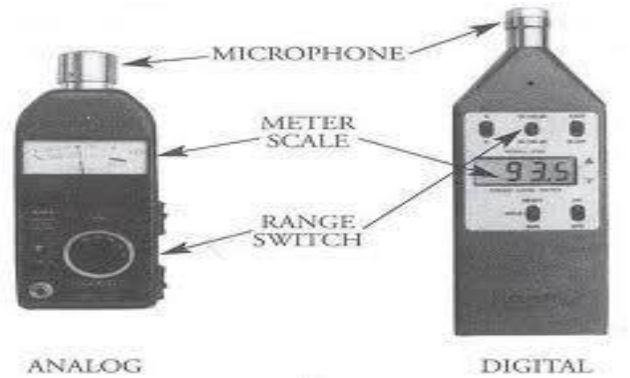

Figure 1: Analog and Digital Sound Level Meters

Efforts to control noise are usually aimed at lowering the sound intensity from the noise source. In studying acoustic phenomena in an enclosure, it is necessary to distinguish between sound absorbing materials (i.e. materials that absorbs some of the energy in an incident sound wave and reduce reflections) and materials which reduce the transmission of sound. Usually, there are three ways of eliminating unwanted sound which entails eliminating the sound at source, modifying the path along which the sound energy is transmitted and providing a receiver with some form of protection.

In some cases, controlling noise at the source will be sufficient, in other cases, it may be necessary to control the noise at each step of the system. We attempt to reduce radiated acoustic power here by monitoring with a sound level meter and alerting library users in cases of increasing noise level.

I.5 Project Block Diagram

This project measures sound pressure level consistently by means of a microphone that picks up the sound signal and converts it to an electrical signal that is then amplified by the pre-amplifier as shown in the block diagram of Figure 2. This lightly amplified signal is sent to the microcontroller [4] which constantly compares it with the pre-set critical valuebased on amicro-program installed in it. If the sound pressure level exceeds the pre-set value, the microcontroller sends a signal to the voice processor circuit and then it plays the recorded message that is amplified by the power amplifier thereby warning library users in the process.

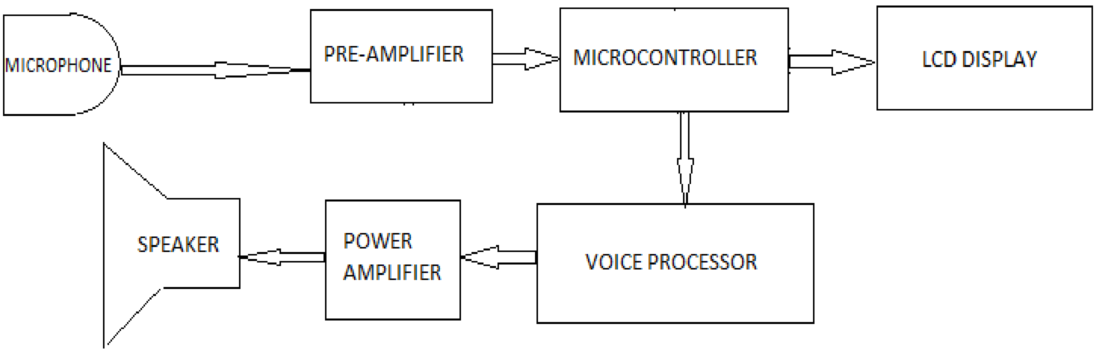

Figure 2: Project Block Diagram showing areas of interest.

The above block diagram represents a basic view of what the entire project entails which we shall understand as we go on further with this work.

I.6 Project Application Area

The Sound Level Meter can be applied in several different ways as follows:

- **General Purpose:** General purpose sound level meters meet the strict international standards. These sound level meters are designed for use in general noise surveys. They are easy to use and give clear results on the built- in LCD display [5].
- **Product Testing:** Sound level meters are used for testing the noise from products and alarms. These are general purpose sound level meters that are suitable for many product testing applications, such as fire alarms, lawn mowers and other machinery.
- **Noise at Work:** Sound level meters can be used for measuring noise at work and occupational noise exposure for workers. These sound level meters aredesigned to meet the demanding requirements and

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standards of governing regulations. They are designed to be easy to use but still provide you with all the noise measurement parameters that you need in an accurate and reliable manner.

- **Environmental Noise:** Sound level meters can be used for monitoring environment and community noise levels. These sound level meters are suitable for the measurement of environmental or community noise. This can be noise coming from factories, road traffic or noisy residents. All these meters are hand-held and battery powered and some could have weatherproof cases and microphones available.

II. LITERATURE REVIEW

II.1 The Sound Level Meter

The meter considered in this project is a digital equipment with the ability to effectively sense, measure, compare and regulate varying sound levels in a library since we are concerned with the noise in a library and a means to eliminate it via audio announcement that is incorporated into the sound level meter.

If a sound source of power is turned on in a quiet room (a library in this case), sound will travel outward from the source and eventually impinge on a surface boundary of the room. Some would be absorbed by the boundary and the remainder would be reflected back into the room. If the sound source is turned off, the sound in the room will continue to reverberate until the level of acoustic intensity decays to a value equal to the ambient intensity of the room. With this knowledge, modern libraries are gradually incorporating the use of sound level meters in their daily operation to monitor varying sound levels.

Features of the Sound Level Meter include:Pre-amplifier stage, Microcontroller, Power amplifier stage, Voice Processor stage, and LCD Display.

II.2 Pre Amplifier Stage

A pre-amplifier (pre-amp) is an electronic amplifier that prepares a small electrical signal for further amplification or processing. A pre-amplifier is often placed close to the sensor (in this case the microphone) to reduce the effects of noise and interference. It is used to boost the signal strength to drive the cable to the main instrument without significantly degrading the signal-to-noise ratio (SNR). The noise performance of a pre-amplifier is critical; when the gain of the pre-amplifier is high, the SNR of the final signal is determined by the SNR of the input signal and the noise figure of the pre- amplifier. In this case, this can be referred to as an operational amplifier because it is used widely in measuring instruments for signal processing and in circuits that perform mathematical algorithmic functions, or 'operations' on input signals to obtain specific types of output signals. Modern Op-amps are usually provided as integrated circuits, rather than constructed from discrete components.[4]

The pre-amplifier stage employs series of resistors and capacitors coupled with the operational amplifier in order that the desired level of amplification is achieved via a tested circuitry. Therefore we take a look at both resistors and capacitors.

II.3 Power Amplifier Stage

The term 'power amplifier' is a relative term with respect to the amount of power delivered to the load and/or sourced by the supply circuit. This is an electronic device that increases the power of a signal. It does this by taking energy from a power supply and controlling the output to match the input signal shape but with larger amplitude. In this sense, an amplifier modulates the output of the power supply. Therefore in general, a power amplifier is designated as the last amplifier in a transmission chain (the output stage) and is the amplifier stage that typically requires most attention to power efficiency. Efficiency considerations lead to various classes of power amplifier based on the biasing of the output transistors or tubes. A power amplifier normally drives the loudspeaker since it can be referred to as an audio amplifier seeing as it amplifies audio frequencies. This amplifier also employs several resistors, capacitors and transistors.

II.4 Voice Processor Stage (Play and Record Chip)

TheWinbond ISD1790 Chip-Corder is a high quality, fully integrated, single-chip multi-message voice record and playback device ideally suited to a variety of electronic systems. The message duration is user selectable in ranges from 26 seconds to 120 seconds based on this specific device. The sampling frequency of this device can also be adjusted from 4 kHz to 12 kHz with an external resistor, giving the user greater flexibility in duration versus recording quality for each application. Operating voltage spans a range from 2.4 V to 5.5 V to ensure that the ISD1790 device is optimized for a wide range of battery or line-powered applications. The ISD1790 is designed for operation in either standalone or microcontroller (SPI) mode. The device incorporates a proprietary message management system that allows the chip to self- manage address locations for multiple messages. This unique feature provides sophisticated messaging flexibility in a simple push-button environment. The device includes an on-chip oscillator (with external resistor control), microphonepreamplifier with Automatic Gain Control (AGC), an auxiliary analog input, anti- aliasing filter,

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Multi-Level Storage (MLS) array, smoothing filter, volume control, Pulse Width Modulation (PWM) Class D speaker driver, and current/voltage output.[5][6]

III. RESEARCH METHODOLOGY

Over the years, several studies have been carried out on libraries of different universities within Nigeria and the world over to evaluate the noise problem plaguing these Institutions. The physical environment conditions of a library are essentially as important as the resources that a library can count upon as either sources of strength or sources of weakness. Environmental factors, namely, ventilation, noise and physical facilities of a library such as library furniture and lighting, are variables that are likely to influence the use of the library. Good ventilation should always be provided in the university libraries hence librarians are admonished to carry out periodic environmental surveys in order to ensure that there is always good air circulation around the reading areas since it is generally believed that just as vision is important to learning through reading, so also is a wholesome auditory environment which is required for concentrated reading and study.

To be able to concentrate on tasks in a library such as reading and writing, there is need for the control of noise, as it is generally agreed that noise and other distractions are fundamental obstacles to learning in a library.

Adequate ventilation is a good factor necessary for adequate reading and learning or research to take place in any university library. Functional library must be with air conditioners, ceiling fans and windows with cross ventilation, it is also important to keep an eye on the quality of air inside the library where the students spend most of their time searching for information since this effort will facilitate the students understanding of their studies. It is almost impossible for any reader to either read or do proper research without a good ventilated library especially in Nigeria been a hot weather environment. Georgina and Nwalo[7]found in their study that libraries in some selected universities in Nigeria are adequately illuminated as 61.6% of the respondents agreed and strongly agreed to the adequacy of ventilation in academic libraries.

An ideal learning environment can be described as that which all the learning enabling factors such as adequate ventilation, noise-free reading areas, adequate lighting and adequate furniture is provided. Nwalo[8] found out that environmental factors such as lighting ventilation, reading space, conveniences and user friendly policies have great effect on library effectiveness. Alutu and Ojogwu[9] and Nwadiani[10]noted that in most universities in Nigeria, classrooms are overcrowded and poorly ventilated. It is not an over-statement to say that what affects students in the classroom had its effects in the library. Study rooms serve not only to keep books or collection of software and computers. It also contains furniture, ventilation appliances and more. These can be located in the house or library. Various types of libraries are available and these include public, national, educational and special libraries.

Libraries require quietness, thus sound should be controlled whenever noise may adversely affect the working conditions, comfort as well as the health of the library users. Sources of noise in the libraries include sound from electrical appliances, (photocopiers, air conditioners or other ventilation gadgets etc.), as well as users' noise from outside the libraries which include motor vehicles, humans and many more. Many libraries (room elements) lack proper surface finishes which are very good sound absorbers such as prefabricated acoustic units, acoustic plasters and sprayed on materials. Acoustic silence can be used to attenuate sound from ventilating systems. Common materials used in most libraries which reflect sound by producing echoes includesteel glass, aluminum, untreated wood, concrete,and terrazzo.

One of the objectives of this project is to feasibly study data for building element, materials, furniture, finishes and users by eliminating sound at the source, modifying the path along which the sound energy is transmitted and installing sound absorbers possibly. Sound requires a source, a medium for transmission, and a receiver.[11] Sound waves are elastic waves that may be produced by vibrating bodies on air turbulence.[12]

In general, the higher the absorption coefficient of the elements and furniture, the higher is the room constant and lower sound pressure level. The result obtained in this project would be extremely beneficial to the fields of Structural and Environmental Engineers in the design of a Library reading rooms. The room constant derived in this work can be used to determine the sound pressure level of a library room with respect to all criteria as observed in this work.

IV. DESIGN AND IMPLEMENTATION

IV.1 Software Development Process

The software was developed in a systematic and sequential manner so as to derive high quality software that meets the required standard.

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IV.2 Design Model

In this work, we used the Waterfall model [13] to design and implement our software. The waterfall model is a sequential design process, often used in software development processes, in which progress is seen as flowing steadily downwards (like a waterfall) through the phases of Conception, Initiation, Analysis, Design, Construction, Testing, Production/Implementation and Maintenance.

The waterfall development model originates in the manufacturing and construction industries: highly structured physical environments in which after-the fact changes are prohibitively costly, if not impossible. Since no formal software development methodologies existed at the time, this hardware-oriented model was simply adapted for software development.

It states that the phases are organized in a linear order. The model was originally proposed by Royce. In this model, a project begins with feasibility analysis. Upon successfully demonstrating the feasibility of a project, the requirements analysis and project planning begins. The design starts after the requirements analysis is complete, and coding begins after the design is complete. Once the programming is completed, the code is integrated and testing is done. Upon successful completion of testing, thesystem is installed. After this, the regular operation and maintenance of the system takes place. The model is shown in figure 3. In each of these steps, the products produced were evaluated and certified.

We adopted this process model because of its numerous advantages. It is simple, straightforward, and division of the large task of building a software system. It alsoallows for departmentalization and managerial control.

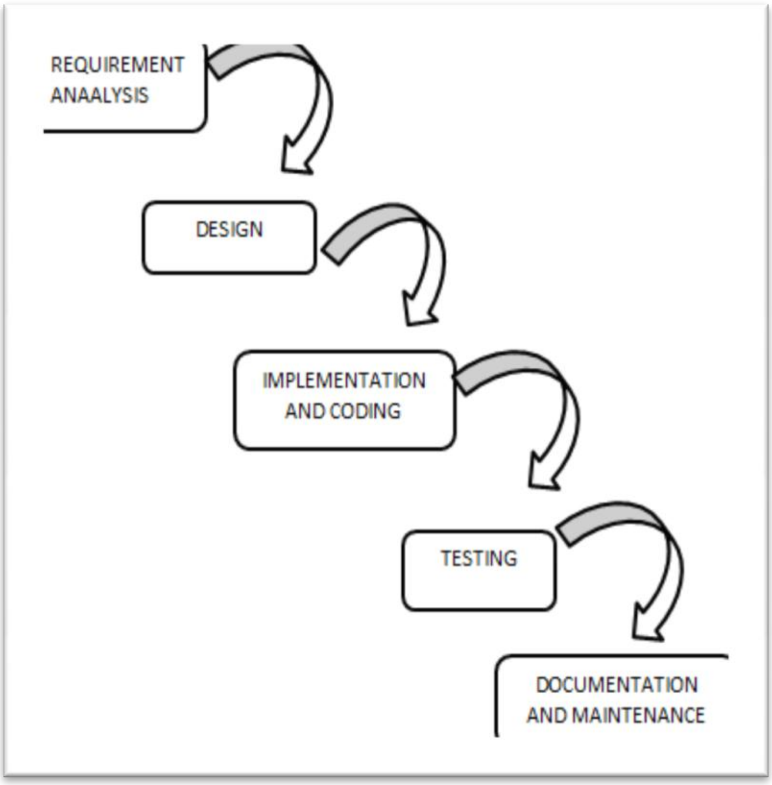

Figure 3: The Waterfall Model

IV.2.1 Requirement Analysis

Requirement analysis is a very important aspect of the development of a project (software) because it helps the developer to have a clear knowledge of the problem to be solved and hence determine how best to solve the problem. In this phase of development, we interrogate what is needed from the system and make a documentation of these requirements in a Software Requirements Specification (SRS) document.[14]

Software Requirement Specification (SRS) Document: The SRS document highlight consists of three main parts namely: Focus, Constraint and Hardware. The Focus is what you are looking up to. It means what you intend to achieve at the end of the project. The Constraint shows what the project is supposed to guard against. It shows what should never occur while the project is installed and used. The Hardware shows the electronic equipment that is needed for the proper execution and function of the project.Table 1 below describes this document.

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Table 1: Sample Software Requirement Specification (SRS) Document

SAMPLE SOFTWARE REQUIREMENT SPECIFICATION (SRS) DOCUMENT	
Focus	➢ The software application must show and simulate on an LCD, the sound level in the library at every instance. ➢ The software should have the ability to detect sound levels above the stipulated maximum allowable sound level for a library and act appropriately. ➢ The software should be designed in such a way that the maximum allowable sound level of the system can be set at any time using a keypad.
Constraint	➢ No unauthorized management should ever occur. ➢ The users of the library should never have access to the management software.
Hardware	➢ Constant power supply must be provided. ➢ An audio announcement setup must be provided with the capacity to relay the audio message to the entire library. ➢ The LCD screen has to be placed in a manner such that it is visible to all.

IV.3 Design

Here, the requirements acquired are translated into a representation of the system using design techniques such as flow charts, data flow diagrams and structure charts. Figure4.2 shows a flow chart representing the requirements of our software.

IV.4 Implementation and Coding

In coding, we translate the design into machine readable form using a programming language. The programming language we used is MikroClanguage [15] and the Integrated Development Environment (IDE) used is MikroC Pro for PIC. The codes algorithm are as described in the flow chart of figure 4.

IV.5 Testing

The primary purpose of testing is to detect and correct software malfunctions and errors. Testing would help show how well a software functions under varying conditions. We carried out two types of testing. Firstly, as we wrote our codes, we used a simulation software application (Proteus 7Professional) to constantly simulate the codes and determine areas that require amendment or correction. This application has some limitations as it may not recognize some inherent problems that could only be discover in real-time.Secondly, we tested the codes by burning the codes into the microcontroller and testing it in real-time with the microcontroller connected in an appropriate circuit board.

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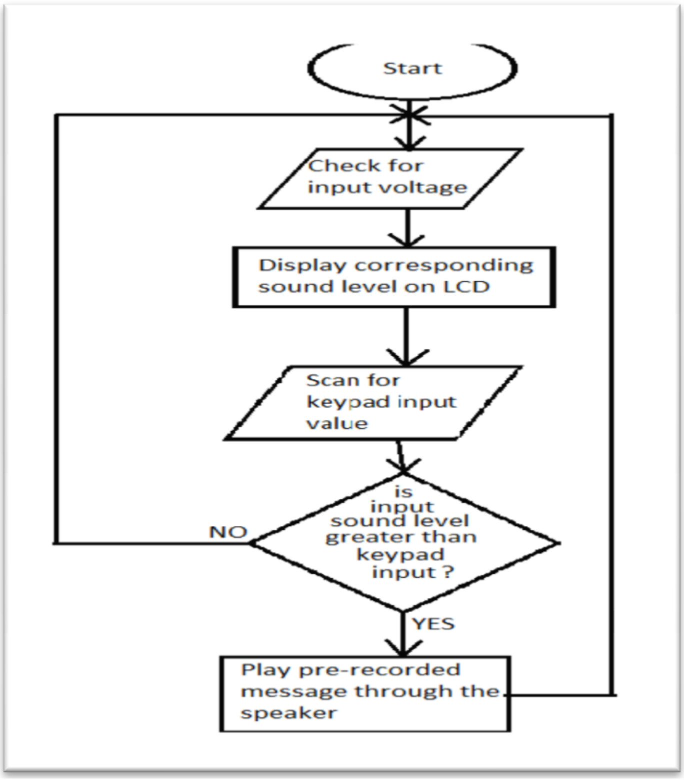

Figure 4: Flowchart representing the Requirements of our Software

IV.6 Documentation and Maintenance

All the activities that were undertaken in the process of developing this software as well as the codes written were properly documented so as to aid traceability and understandability of the modules and the interface between them. This results to good qualities of the software such as reliability, maintainability, and flexibility. Maintenance can be corrective, preventive or adaptive.

IV.7 Hardware Development Process

In this project, we designed two major modules: the voice processor and the microcontroller modules.

IV.7.1 Voice Processor Design

The voice processor is designed in such a way that a message is pre-recorded and would only be played if it receives a signal from the microcontroller. It consists of a play and record chip (ISD1790) circuit, and a power amplifier circuit. The power amplifier is necessary to drive a large speaker capable of sending the audio message across the entire library.

IV.7.2 Sound Level Meter Design

This consists of a condenser mic, a pre-amplifier circuit and a microcontroller circuit. Figure 4.4 below shows the circuit diagram representing this design, comprising of themicrocontroller, LCD screen and keypad amongst other components. In this design, a potentiometer (component RV2) is used to represent the varying input of the pre- amplifier circuit and an LED (component D11), is used to monitor the output signal of the PIC to the voice processor module.

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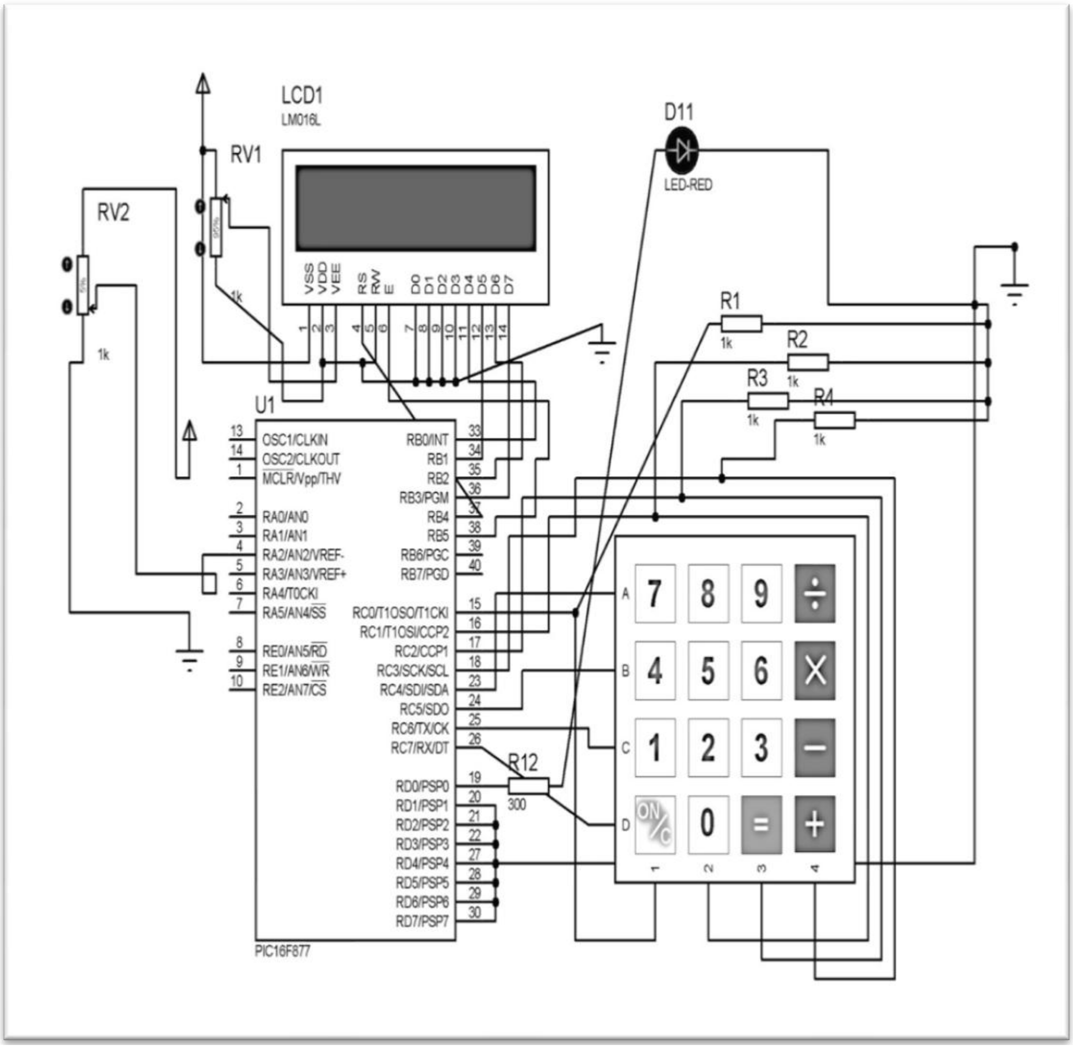

Figure 5: Circuit Diagram Showing Sound Level Meter Design.

V. CONCLUSION

V.1 Project Summary

A sound level meter is simply a device with audio-frequency sensing capabilities that is controlled essentially by a microcontroller in turn measuring, comparing and regulating audio signals all in a bid to reduce noise level in a library as well as maintain a stable audio frequency throughout the library environment. This project focuses on measuring the various sound levels present in a library all in a bid to limit unnecessary noise in the library through audio announcement once the critical sound level has been exceeded.

This sound level meter consists of a Condenser microphone (used as an input device to convert the sound into electrical signal), Pre-Amplifier (amplifies the electrical signal), Microcontroller (with internal ADC programmed to compare the input signals with a critical value to detect when there is noise), Play and Record Chip (to play a pre- recorded message to alert users of the library to increasing sound level), Power Amplifier (amplifies the output of the play and record chip) and LCD display (displays the sound levels).
The Sound Level Meter measures sound level in decibels and can be used for activities such as environmental noise studies, sound level comparisons, investigating room acoustics, sound isolation modeling, sound propagation modeling etc. It can be applied in libraries, hospitals, laboratories, lecture rooms, meditation rooms amongst many others.

V.2 Recommendations

Intra-Faculty collaboration between Electrical and Electronic Engineers should be encouraged in any Electronic/Electrical-based projects like this; so as to result in a successful and working project.

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Sound Measurement lectures should be made more practical and simple to understand without avoiding its complexity. This would aid and facilitate the actualization of projects that require either wholly or partly the implementation of Sound Level Meters.

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