DESIGN AND CONSTRUCTION OF A DIGITAL TALKING VOLTMETER

BY

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EEE/11/0391

A PROJECT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, FEDERAL UNIVERSITY OYE-EKITI, NIGERIA

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN ELECTRICAL AND ELECTRONICS ENGINEERING

SEPTEMBER, 2016.

DECLARATION

I declare that this project was carried out by me under the supervision of Dr. Engr. A.M. Zungeru of the Department of Electrical and Electronics Engineering, Federal University, Oye - Ekiti, as part of the requirement for the award of Bachelor Degree of Electrical and Electronics Engineering. Sources of Information are specifically acknowledged by means of reference. I solemnly declare that this work has not been submitted elsewhere for the award of any Degree.

.... 26/10/2016

Signature Date

CERTIFICATION

This is to certify that this project was written by ICHIE, Chukwumaobi Ichie (EEE/11/0391) under my supervision and is approved for its contribution to knowledge and literary presentation. All sources of information are specifically acknowledged by means of references, in partial requirements for the award of Bachelor of Engineering (B.Eng.) degree in Electrical and Electronics Engineering, Federal university Oye-Ekiti, Ekiti, Nigeria.

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I am grateful to my parents whose foundation of hard work and honest lifestyle has helped build me into who I am, my siblings who spared nothing in helping me in every of my desire to succeed, my friends, who have been a huge positive influence in my life, a gift from God Himself and my colleagues who created a healthy competition to thrive and to push me to come out on top and to everyone who spared a second to give me good advice. Thank you and God bless you.

DEDICATION

This project is dedicated to the loving memories of Daddy.

ABSTRACT

This project work presents the design and construction of a Talking Voltmeter. This device is built around an ISD1110P (a voice recorder and playback Integrated Chip (IC)), a PIC microcontroller based digital voltmeter with LCD output and LEDs outputs. PIC16F873A was used for digital display, LEDs for analog light outputs and ISD1110P for voice output. The Talking voltmeter gives a numerical display of voltage by use of an analog to digital converter, which is an electronic device that converts an input analog voltage or current to a digital number proportional to the magnitude of the voltage. Since the display is digital, there is no parallax reading error that occurred. The meter uses liquid crystal display (LCD) to display digital value because it has low power consumption, lower than light emitting diodes (LED). This is then followed by interfacing to a record and playback IC. This IC speaks out the corresponding voltage value unit through the speakers. The system is partly controlled by microcontroller, and partly by the analog circuitry to produce the voice output. The system was tested in the laboratory and works according to design specifications. The project finds application in engineering laboratories, workshops and all engineering work stations where voltage readings and measurements are required thus providing a practical tool to measure voltages with both visual display and a voice output.

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ABBREVIATIONS

ADC –	Analog to Digital Conversion
A/D –	Analog or Digital
AC –	Alternating Current
CMOS -	Complementary metal–oxide–semiconductor
DVM –	Digital Voltmeter
DC –	Direct Current
EEPROM -	Electrically Erasable Programmable Read-Only Memory
IC –	Integrated Circuit
I/O –	Input or Output
ISD –	Instructional System Design
LCD –	Liquid Crystal Display
LED –	Light Emitting Diode
MCU –	Microcontroller Unit
PIC –	Peripheral Interface Controllers
PDIP –	Plastic dual in- line Pin
SD -	Secured Digital

CHAPTER ONE

INTRODUCTION

1.1 PREAMBLE

A voltmeter is used to measure voltage in circuits. It is a common practice to measure and look at the readings or measurements on the LCD of the voltmeter. At times, by looking at the readings and at the same time measuring the circuit using probes causes the connection between the test points to get loose or gets disconnected. As humans, we cannot do two separate things and concentrate our eyes on both the circuit and the voltmeter.

This has also been a problem for so many students during laboratory sessions and because of this, the reading of the measurement might be incorrect or mistakenly measured. Sometimes to measure a complex circuit needs careful handling of the probe in order not to touch the incorrect point as not to short circuit the circuit itself. Two people were required sometimes to measure a circuit, one to hold the probe in and another to read and write down the reading of the measurement. By creating this talking voltmeter, a person who uses a voltmeter to measure can now measure a test point without seeing the LCD to get the results. The readings will be read out as a sound via a small speaker to enable the user to hear the results.

By having sound as the output, the measurements can be easily gained and the person who measures the circuit will have an easier way of utilizing his time as the person will not be getting any wrong readings. This could save time and avoid unnecessary stress.

1.2 STATEMENT OF PROBLEM

As it is nowadays, measurements specifics are carried with the help of two personnel which leads to time wastage and reduction of manpower.

This problem calls for a device that will be a practical tool to measure voltages with both a visual display and voice output. The device is to measure voltages and provide the value of such voltage via a voice output, LCD display and LED ranges. The measured values are received by a positive and negative probe terminal, where the power source could either be a 9V DC battery or a standard 220V AC power supply for the device.

The proposed solution to this problem is a Talking Voltmeter. In implementing the talking voltmeter, we have two major sections, a PIC circuitry providing an LCD display of the voltage values and a voice playback IC that obtains its addressing via LED ranges connected to diodes.

This Talking voltmeter shall be capable of measuring voltages up to 25V for the PIC section and 10V for the voice playback section.

1.3. PROJECT AIM

The aim of this project is to design and construct an enhanced voltmeter so that the currently available voltmeter has the capability to output voice or sound when measured. This will make the life of a user who uses this talking voltmeter to measure voltages easier during voltage readings in a voltmeter.

1.4. OBJECTIVES

The main purpose of implementing this project is to have a working prototype of a talking voltmeter providing a practical tool to measure voltages with both visual display and a voice output.

The main objectives are outlined as:

1. To design a device that receives an input signal, measures the voltage value and display the magnitude of such value via the LCD and LEDs ranges.
2. To design a device that receives an input signal measure the voltage values and voice out the measured value.
3. To design a device that will receive its signal input from the positive and negative terminals of the device.
4. To design a device capable of measuring voltages up to 25V for the PIC section and 10V for the LED and voice playback section.
5. To implement, design and construct a talking voltmeter in our laboratory.

By starting this project, smaller objectives are achieved such as:

- Learn how to build a circuit

- Learn how to program a microcontroller
- Learn programming
- Learn troubleshooting
- Learn PCB etching
- Learn how to integrate the circuit to work with the software/coding
- Be able to use a voltmeter to get a reading to compare with the talking voltmeter
- Able to confirm the reading with the original value
- Be able to demonstrate the LCD is working
- Learn how to program sound/voice into the microcontroller
- Able to demonstrate the voice output is the correct reading with the LCD display

1.5.SCOPE OF STUDY

This project concentrates on a development of a talking voltmeter. To develop the whole project, it consists of two major sections, the microcontroller and the voice playback IC. Both sections entail an electrical structure and programming.

For the microcontroller the electrical structure consist of the microcontroller circuit, used to control the whole operation of analog to digital conversion and display of voltages on the LCD. While the software programming is based on the microcontroller instruction sets, it contains a program designed for ADC as an interaction to operate the electrical structure.

Also, the voice play back section has an electrical structure which includes diodes providing digital addressing for the voice playback IC and requires programming for inputting voices into the addresses.

This Talking voltmeter allows the user to measure voltages, providing visual display of the outputs via LCD and LEDs and also a voice output.

1.6.SIGNIFICANCE OF THE STUDY

The project is intended to make a talking voltmeter more accessible to users which are cost efficient and have a highly functional design. It also reduces multi-tasking and errors while taking measurements of voltage values. The project is highly significant for people who have sight disability as they are able to partake in electrical projects that require voltage ranges and also for the calibration of bench power supply without digital resolutions or partitioning.

The purpose of this project is to test and challenge the academic knowledge that has been gained so far throughout our entire course period of five years. This project requires us to utilize knowledge from all our subjects. All parts and parcels of this project are expected to work well in order to achieve perfect project function.

In upcoming years, an advanced version of this project will be built incorporated with the latest technology and more advanced features. This project is expected to be the model for future talking voltmeter around the world.

1.7. METHODS OF STUDY

1.7.1 PROJECT FLOW

- Research
- Planning
- Designing
- Troubleshooting
- Testing
- Final Project Report
- Troubleshooting
- Testing

At the start of the project, research was done to ensure all the information regarding the project is compiled and further studied. After the research process, planning on how to make all the necessary preparation to start the project was done. In planning, a lot of things were planned such as the time frame, how to get components, basic workings of the project, work flow and also budgeting.

The next step was designing the project from the circuit diagram to the process flow of the project. After designing, troubleshooting was carried out to make sure there are no problems in the design of the hardware or the software. Testing was done to make sure that the circuit works as par design specification and can be able to make measurements. Further troubleshooting and testing is done when there were some more bugs in the circuit and programming. Finally, final reports is then prepared.

1.7.2 PROJECT PLANNING

Throughout this entire project, a proper planning has been carried out to identify the tasks and also as a guideline to complete this project. This project was organized based on ideas from literature survey and discussion through many source and information gather from internet web sites and books. The tasks are arranged as follow:

- Literature Survey
- Project Design (Hardware and Software)
- Circuit Testing
- Project Construction
- Troubleshooting

1.7.3 BLOCK DIAGRAM

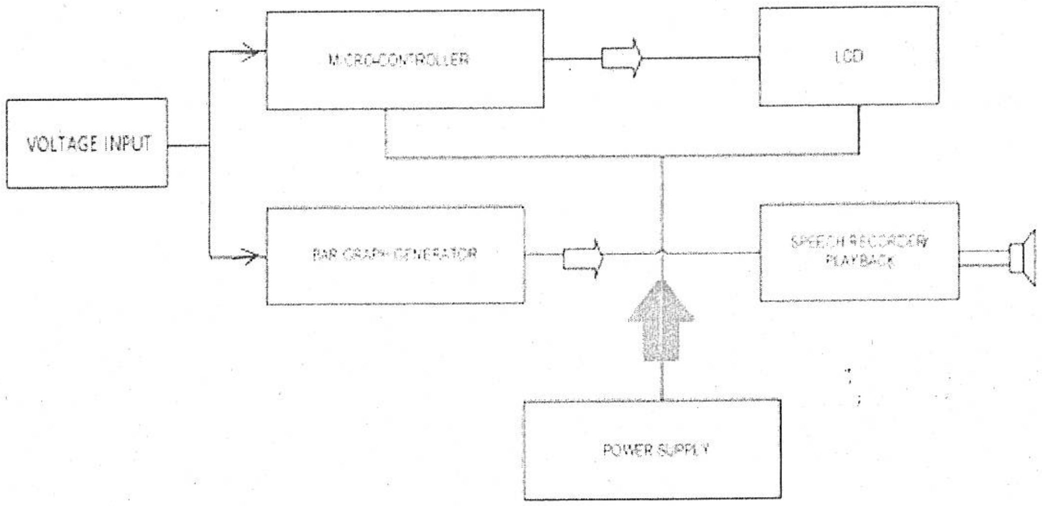


Figure 1.1: Block Diagram of Talking Voltmeter

The primary functional blocks and assembly sections of this circuit/design are:

1 - The voltmeter - LM3914

2- The power supply - 78L05

3 – The Clock pulse generator - CD 4011

4 – The digital address encoder - Diodes 1N4148

5 - The audio recorder ISD1110P

6 - PIC16F873A

7 - LCD Display

8 - Speaker

The block diagram of the talking voltmeter is provided Figure 1.1. As can be seen in Figure 1.1, the PIC16F873A gets its own the input and output of the circuit. The probes act as an output where it is used to measure circuits and the signal is sent to the microprocessor (MPC). The MCU will process the input and calculates the output and displays it on the LCD display.

Also signal will be sent to the voice playback chip and it will output voice recording to the speaker.

1.7.4. LOGIC STRUCTURE:

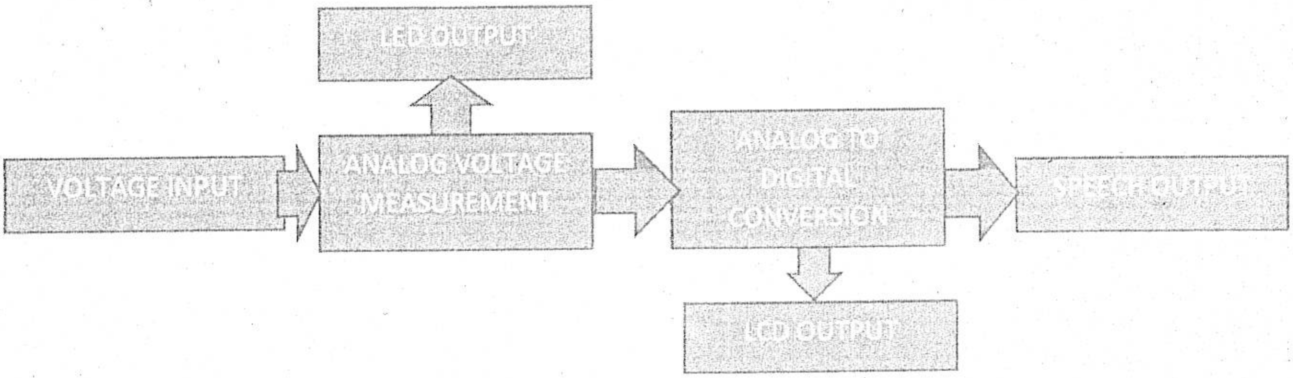


Figure 1.2: logic structure of talking voltmeter

1 - The voltmeter - LM3914 (Analog voltage measurement)

2- The power supply - 78L05

3 – The Clock pulse generator - CD 4011

4 – The digital address encoder - Diodes 1N4148 (Analog to digital conversion)

5 - The audio recorder ISD1110P

6 - PIC16F873A (Analog to digital conversion)

7 - LCD Display

8 – Speaker

Where first the LM3914 acts as a dot graph for ten analog output, providing thus an analog voltmeter and this is interfaced with the diodes IN4148 which acts as the ADC converting the analog inputs entering the LM3914 to a digital input of binary address i.e. a digital address encoder, which will feed into the audio recorder ISD1110P thus giving out outputs through the speaker.

The PIC16F873A also acts as an ADC with its output displayed on an LCD giving a digital display to the analog output of the LM3914 and the speaker output.

CHAPTER 2

THEORITICAL BACKGROUND

2.1. BACKGROUND

This chapter provides an introductory background to a Talking Voltmeter, starting from ordinary voltmeters to talking voltmeters. It is valuable to examine existing researches and innovations that are related to the technology used in this system. It also gives examples of implemented project design and its contribution.

A voltmeter is an instrument used for measuring electrical potential difference between two points in an electric circuit. Analog voltmeters move a pointer across a scale in proportion to the voltage of the circuit; digital voltmeters give a numerical display of voltage by use of an analog to digital converter.

Voltmeters are made in a wide range of styles. Instruments permanently mounted in a panel are used to monitor generators or other fixed apparatus. Portable instruments, usually equipped to also measure current and resistance in the form of a multimeter, are standard test instruments used in electrical and electronics work. Any measurement that can be converted to a voltage can be displayed on a meter that is suitably calibrated; for example, pressure, temperature, flow or level in a chemical process plant [1].

Analog voltmeter

A moving coil galvanometer can be used as a voltmeter by inserting a resistor in series with the instrument. The galvanometer has a coil of fine wire suspended in a strong magnetic field. When an electric current is applied, the interaction of the magnetic field of the coil and of the stationary magnet creates a torque, tending to make the coil rotate. The torque is proportional to the current through the coil. The coil rotates, compressing a spring that opposes the rotation. The deflection of the coil is thus proportional to the current, which in turn is proportional to the applied voltage, which is indicated by a pointer on a scale.

One of the design objectives of the instrument is to disturb the circuit as little as possible and so the instrument should draw a minimum of current to operate. This is achieved by using a sensitive galvanometer in series with a high resistance.

The sensitivity of such a meter can be expressed as "ohms per volt", the number of ohms resistance in the meter circuit divided by the full scale measured value. For example, a meter with a sensitivity of 1000 ohms per volt would draw 1 milliampere at full scale voltage; if the full scale was 200 volts, the resistance at the instrument's terminals would be 200,000 ohms and at full scale the meter would draw 1 milliampere from the circuit under test. For multi-range instruments, the input resistance varies as the instrument is switched to different ranges.

Moving-coil instruments with a permanent-magnet field respond only to direct current. Measurement of AC voltage requires a rectifier in the circuit so that the coil deflects in only one direction. Some moving-coil instruments are also made with the zero position in the middle of the scale instead of at one end; these are useful if the voltage reverses its polarity.

Voltmeters operating on the electrostatic principle use the mutual repulsion between two charged plates to deflect a pointer attached to a spring. Meters of this type draw negligible current but are sensitive to voltages over about 100 volts and work with either alternating or direct current [1].

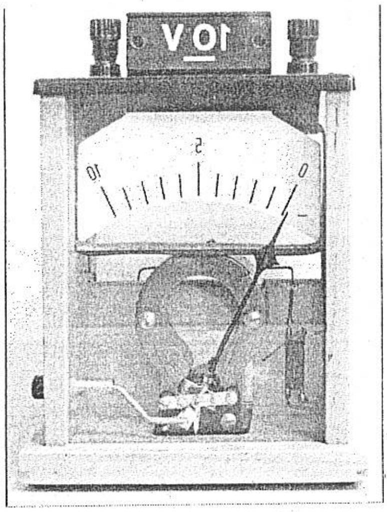


Figure 2.1 Analog Voltmeter

Digital voltmeter

A digital voltmeter (DVM) measures an unknown input voltage by converting the voltage to a digital value and then displays the voltage in numeric form. DVMs are usually designed around a special type of analog-to-digital converter called an integrating converter.

The first digital voltmeter was invented and produced by Andrew Kay of Non-Linear Systems (and later founder of Kaypro) in 1954 [2].

A digital voltmeter is commonly used by all. It is easily accessed and easily used. A digital voltmeter can read values up to two decimal points. It is commonly used by students to conduct laboratory assignments.

One limitation of a digital voltmeter is its inability to voice out the value that a person is measuring i.e. it cannot read out the value that a person is measuring. This has made the life of students and also other users harder as they need to look at the voltmeter to know the reading. It can also be troublesome if the circuit that are being measure is large and the voltmeter cannot be near to the user to see the readings on the voltmeter.

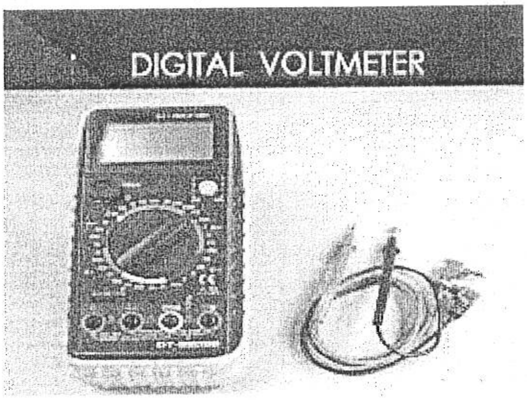


Figure 2.2: Digital Voltmeter

Figure 2.2 is the regular voltmeter which is available in the market at present and is widely used by all. Although using these types of voltmeter gives out correct reading, it is lacking voice to inform the user of the reading or the value on the voltmeter. Hence, measuring would be easier and faster if the regular voltmeter in our market today can voice out our reading at any particular point in time measurement is carried out [1].

Talking Voltmeter

For a talking voltmeter, we have very few companies producing any. One of such with Mike Iwata, president of Micro Seven, a small test and measurement company up in Hillsboro Oregon, produces VM10 multi-meter that has a voice output, its main advantage is that that you can record your voice or anyone else's. The device is expensive for an average person having a price of USD495 (N150,000).

For Micro Seven VM10 multimeter, The VM10 records your own voice and uses that to call out voltage, current and ohms measurements [3].

In other related research Mastro Gippo [4], after a request from one of his friends, [Mastro Gippo] managed to put together a talking multimeter to be used by blind persons working in electronics. He wanted a feature-rich meter that had serial output, and recalling a Hackaday article from a few years back led him to find a DT-4000ZC on eBay, which has serial output on a 3.5mm jack.

It turns out there aren't many talking meter options available other than this expensive one mentioned above and a couple of discontinued alternatives. [Mastro Gippo] needed to start from scratch with the voice synthesizer, which proved to be as easy as recording a bunch of numbers and packing them onto a secure digital (SD) card to be read by an Arduino running the simple SD audio library. He found a small, battery-powered external speaker used for rocking out with music on cell phones and hooked it up to the build, stuffing all the electronics into an aluminum case. Stick around after the jump for a quick video of the finished product [4].

2.2 LITERATURE REVIEW

Major previous works which have been done on a talking voltmeter includes

The Handy Lab Buddy"A Talking Voltmeter" by Cooper Bills and Anish Borkar of cornell university [5]. The four features of this tool include a talking voltmeter, logic probe, voltage averager, and frequency measurer. The first mode is a voltmeter that measures voltages up to 5V and says the voltage measured through speakers. The second mode is a logic probe that beeps once in a low tone if the output voltage is low and beeps twice in a higher tone if the output voltage is high. The third mode, a feature unique to this device, is a voltage averager that takes multiple samples in succession (perhaps a noisy voltage signal), and calculates the maximum, minimum, and mean voltage and speaks the values over a speaker. The fourth and final mode measures frequency with great accuracy from about 10 Hz to 100 kHz and speaks the value over a speaker. Here quite a few features of the Atmel Mega644 MCU to implement this system, such as speech generation and output, multiple ADC conversions, the output of the pulse width modulator (PWM), and some others[5].

Another project work [6], the working prototype of a talking voltmeter by information technology United Kingdom, This work involved the use of the PIC16F877A, an LCD and the voice playback device (ISD4003) which provides high-quality, 3-volt, and single-chip record/playback solutions for 4 to 8 minutes unlike the ISD1110P of just 10 seconds. This is very similar to our project where the differences are the pin difference of the PICs and the voice playback used. Also the handy lab device has a dot graph voltage display for ten outputs via LEDs which is absent in this work [6].

Others works includes:

1. **Design and Construction of a Digital Voltmeter with Led Display Using the ICl7107**

   This project work [7] is on digital voltmeter Using ICL7107. The device is built around a PIC microcontroller based digital voltmeter with seven segment display output.it also uses the ICL7107. The ICL7107 is a high performance, low power, 3.5 digit analog to digital converter. The IC includes internal circuitry for seven segment decoders, display drivers, reference voltage source and a clock. The power dissipation is less than 10mW and the display stability is very high.

The working of this digital voltmeter is simple in that the voltage to be measured is converted into a digital equivalent by the analog-to-digital converter (ADC) inside the IC and then this digital equivalent is decoded to the seven segment format and then displayed. The analog-to-digital converter (ADC) used in ICL7107 is dual-slope type ADC. [7]

2. **Design and Construction of a Digital Voltmeter using PIC Microcontroller 16f877A and Seven Segments Display (0-30v)**

This project work[8] is a PIC microcontroller based digital voltmeter with seven segment display output, Here it is explaining the constructional details of digital panel voltmeter using PIC16F877A microcontroller. It can measure voltage between 0V to 30V DC. Seven segment units are provided for digital voltmeter display which gives clear visibility of digits from long distance comparing to LCD display. Components required for this digital voltmeter using pic microcontroller are: PIC16F877A Microcontroller, Transistor (BC548 x4), Resistor (1KΩ x 5; 10KΩ; 100KΩ; 22KΩ); seven segment Display x8, crystal (20MHz), Capacitor (10μF, 33PF x2).

3. **Design, Construction and Analysis of a Microcontroller Based Digital AC/DC Voltmeter**

Microcontroller based digital voltmeter is an instrument used to measure the AC or DC voltage. The digital display is the main output which is used to indicate the numerical value of measurement. Since the display is digital, so there is no parallax reading error will be occurring. This meter is uses liquid crystal display (LCD) to display digital value because it has low power consumption, lower than light emitting diodes (LED). The entire system is controlled by microcontroller which also operates together with voltage range selector, AC/DC voltage selector and analog to digital (A/D) converter.

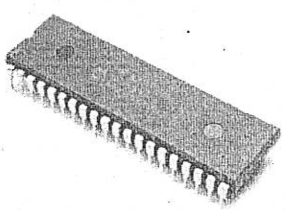
Microcontroller takes controlled of all the functions in the entire system for it is able to function just like a microcontroller based digital voltmeter. The Multi-slope A/D converter provides high resolution conversions in short times-on this system where it can achieve the accuracy of 6%. As the result, the project is going on quite well like LCD display appropriate AC or DC voltage value given by the Peripheral Interface Controller (PIC). For future enhancement, it can add the dB-scale measurement on the root mean square (RMS) converter, and add the serial port to communicate with computer. In conclusion, the project outcomes comply with the aim and objectives of project. [9]

2.3. COMPONENTS AND PROPERTIES

In this sub chapter, discussions are made on components chosen for this project and their properties which best suits to construct the Talking Voltmeter and its applications.

2.3.1. MICROCONTROLLER

The PIC chosen for this project is 28-pin PIC16F873A as shown in Figure 2.4. The 16F873A is one of the most popular PIC microcontrollers and it is easy to interface because it comes in a 28 pin PDIP (Plastic dual in-line) pin out and it has many internal peripherals. The 28 pins make it easier to use the peripherals as the functions are spread out over the pins [10].



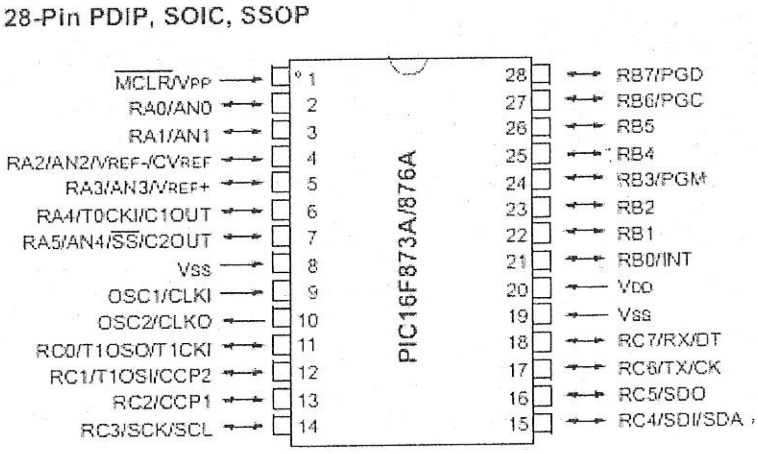


Figure 2.3: Diagram of PIC16F873A

Figure 2.4: 28-Pin PDIP (PIC16F873A)

It is under the 8-bit class microcontroller. It has 5K of FLASH Program Memory, 10-bit A/D converters, 22 I/O pins, 192 byte RAM, 128 byte EEPROM, in-circuit serial programming and other features. It also has RISC (Reduced Instruction Set Computer) architecture. One of the main advantages is that each pin is only shared between two or three functions so it's easier to decide what the pin function [10].

A disadvantage of the device is that it has no internal oscillator so it needs an external crystal oscillator. This PIC can also be reprogrammed and erased up to 10,000 times. Therefore it is useful for new product development phase. There are all flash erasable and re-programmable.

2.3.2. Display Unit (LCD)

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

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. 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 data is the ASCII value of the character to be displayed on the LCD. Click to learn more about internal structure of a LCD [11].

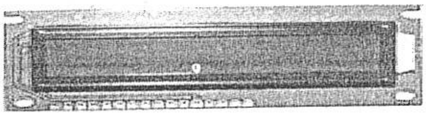


Figure 2.5: 16X2 LCD Display Unit

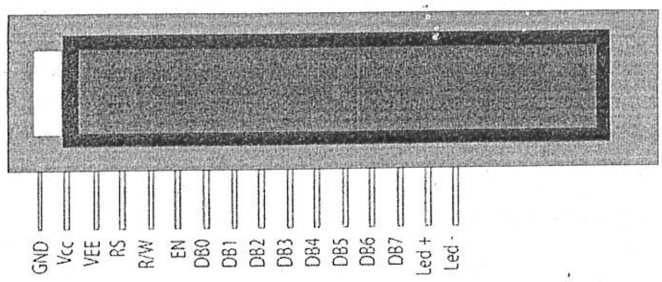


Figure 2.6: Pin diagram for 16X2 LCD Display Unit

Table 2.1: Pin description: The functions of each pin of the LCD

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
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8- bit data pins	DB0
8	8- bit data pins	DB1
9	8- bit data pins	DB2
10	8- bit data pins	DB3
11	8- bit data pins	DB4
12	8- bit data pins	DB5
13	8- bit data pins	DB6
14	8- bit data pins	DB7
15	Backlight Vcc (5V)	Led +
16	Backlight Ground (0V)	Led -

2.3.3. Voice Playback Device (ISD1110P)

ISD1110 chip coder series provides high-quality, single chip record/playback solutions to 10- and 12-second messaging applications. The CMOS devices include an on-chip oscillator, microphone preamplifier, automatic gain control, antialiasing filter, smoothing filter, and speaker amplifier. A minimum record/playback subsystem can be configured with a microphone, a speaker, several passives, two push-buttons, and a power source.

Recordings are stored in on-chip nonvolatile memory cells, providing zero-power message storage. This unique, single-chip solution is made possible through ISD's multilevel storage technology. Voice and audio signals are stored directly into memory in their natural form providing high-quality, solid state voice reproduction [12].

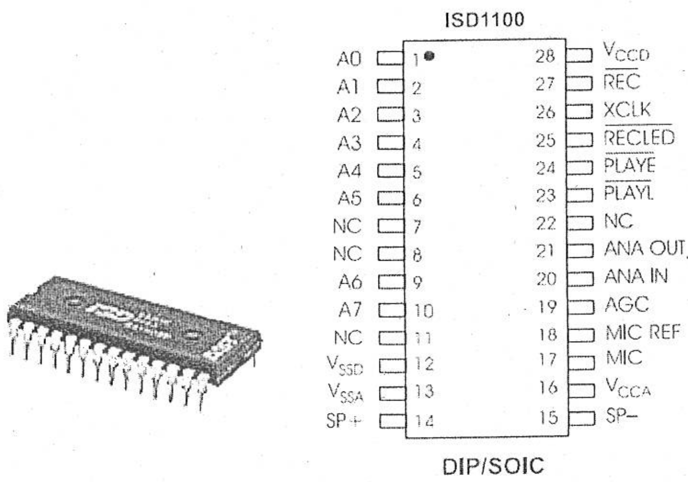


Figure 2.7: ISD1110P

2.3.4. Voltage Regulator

Voltage regulator is a commonly used electrical component in an electrical circuit. The function of the voltage regulator is to convert AC or DC Voltage into DC Voltage and to produce a relatively desired constant voltage. The use of voltage depends on the function of the circuit and application. There are two kinds of voltage regulators, passive voltage regulators and active voltage regulators. A passive voltage regulator reduces the input voltage to a desired value and removes the excess energy by means of heat. Normally, a heat sink is attached to the voltage regulator in order to dissipate the heat. Whereas an active voltage regulator increases the input voltage to a desired value. This is achieved by a of negative feedback loop to control the voltage.

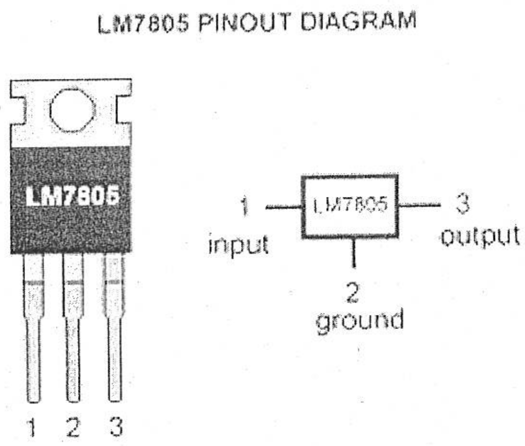


Figure 2.8: Voltage Regulator

For this project, LM7805 is chosen as the voltage regulator shown in figure 2.8 above. It is connected straight to AC power where a DC power adapter then supplies to the voltage regulator so the voltage regulator can provide a constant output voltage of 5V and the maximum output current is 1A to power up the circuit.

2.3.5. Capacitor

Capacitors are widely used in an electrical circuit. It serves as a device which stores energy in the form of an electrostatic field. It is used for several functions such as smoothing power output, blocking direct current and only allowing alternating current to pass through.

2.3.6. LM3914

The LM3914 is a monolithic integrated circuit that senses analog voltage levels and drives 10 LEDs, providing a linear analog display. A single pin changes the display from a moving dot to a bar graph. Current drive to the LEDs is regulated and programmable, eliminating the need for resistors. This feature is one that allows operation of the whole system from less than 3V [13].

The circuit contains its own adjustable reference and accurate 10-step voltage

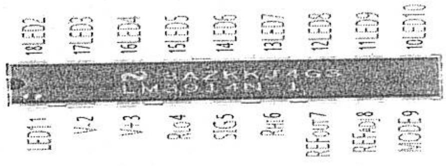


Figure 2.9: LM3914 IC

Table 2.2: Pin functions for LM3914 IC

Pin No	Pin Name	Pin Function	Pin No	Pin Name	Pin Function
1	LED 1	First(lowest value) LED	18	LED 2	2nd LED
2	V^-	Ground	17	LED 3	3rd LED
3	V^+	Supply Voltage (3-25V)	16	LED 4	4th LED
4	R_{LO}	Divider Low voltage	15	LED 5	5th LED
5	Signal In	Analog signal in	14	LED 6	6th LED
6	R_{HI}	Divider high voltage	13	LED 7	7th LED
7	Ref Out	Reference output voltage	12	LED 8	8th LED
8	Ref Adj	Voltage reference adjust	11	LED 9	9th LED
9	Mode	Dot/Bar mode select	10	LED 10	Last(highest analog input) LE

CHAPTER 3

SYSTEM ANALYSIS AND DESIGN

3.1. CIRCUIT IMPLEMENTATION

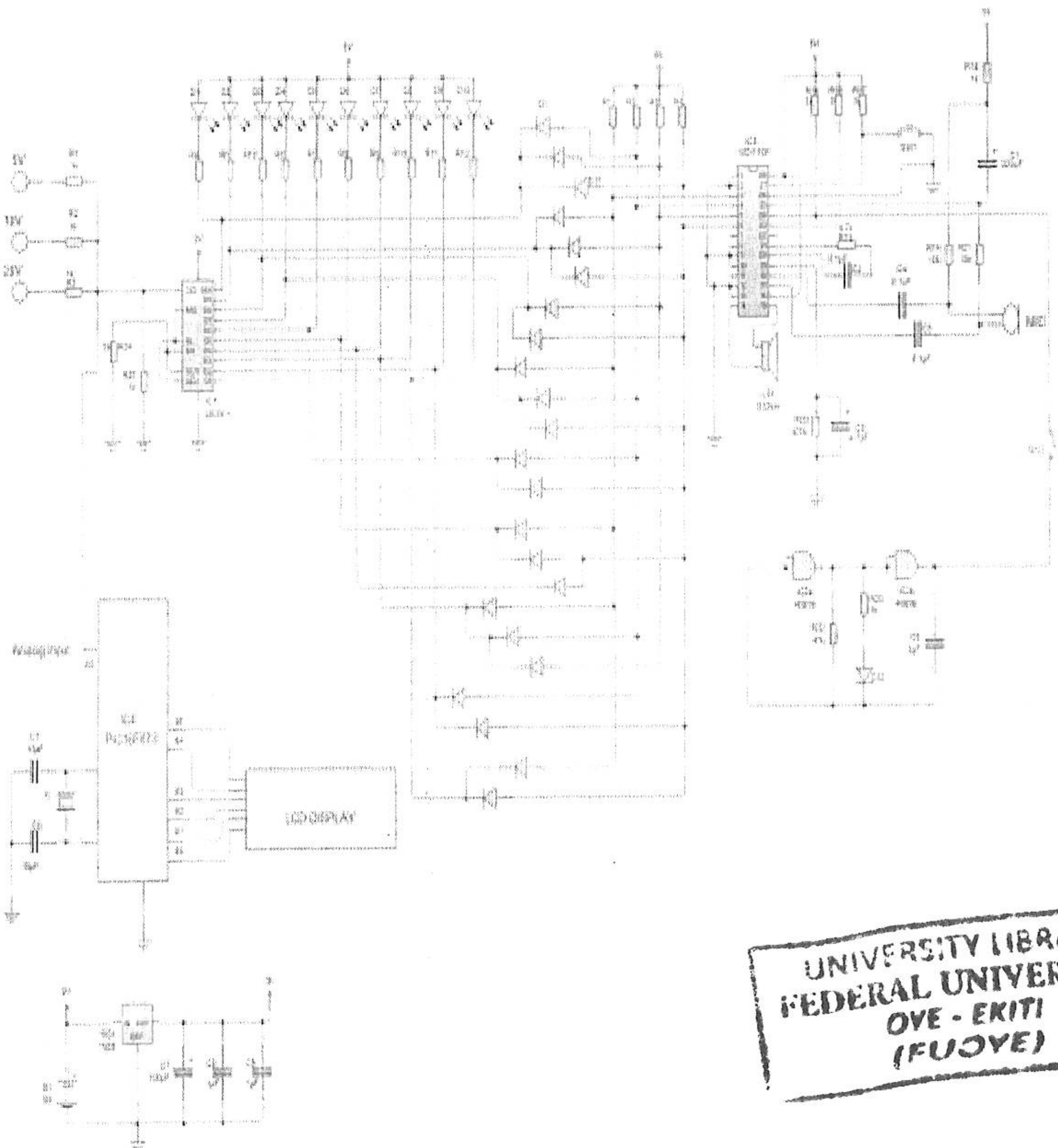


Figure 3.1: Talking Voltmeter Circuit Diagram

The circuit in Figure 3.1 contains the fundamental building blocks consisting of:

1 - The voltmeter - LM3914

2- The power supply - 78L05

3 – The Clock pulse generator - CD 4011

4 – The digital address encoder - Diodes 1N4148

5 - The audio recorder ISD1110P

6 - PIC16F873A

7 - LCD Display

8 - Speaker

3.1.1. DESIGN OF PIC CIRCUIT

The main purpose of this Talking Voltmeter is to measure voltage and then output whatever is being measured through speakers, it's one of its kinds and an essential tool for lab work. PIC16F873A is 5V but the power supply is 9V. If the voltage is more than 5V, it can cause the PIC microcontroller malfunction because the PIC cannot support more than 5V power supply. So, the LM7805 voltage regulator is applied in this control system. LM7805 is used to regulate varying input voltage and produce a constant output voltage of 5V. For maximum voltage regulation, capacitor in parallel between the ground leg and output leg is recommended. This capacitor is used to filter up the signal and produce a smooth output signal. Since PIC16F873A does not have an internal clock a crystal oscillator of 8MHz is connected as external clock source to OSC1 input and OSC2 output where CLKOUT has 1/4 the frequency of OSC1, and denotes the instruction cycle rate.

Project title: LCD-based voltmeter using A/D converter PIC16F873A

Project description: In this project an LCD-based voltmeter is designed. The project can be used to measure and display analog voltages up to +25 V. The voltage is displayed in volts in the following format:

V = nn.n VDC

Figure 3.2: Block diagram for the PIC16F873

Hardware: The circuit diagram of the project is shown in Figure 3.2. In this project a PIC16F73-type microcontroller is used. This is a 28-pin microcontroller with built-in 5 channel A/D converters, each having 8-bits of resolution. Other PIC microcontrollers such as PIC16F673 or PIC16F877, or others with built-in A/D converters can easily be used in this project [14].

PIC16F73 is a 28-pin microcontroller with the following features:

- 8 K flash program memory
- 368 bytes RAM memory
- Up to 20 MHz operation
- 3 timer circuits
- Analog capture, compare and PWM circuits
- 8-bit 5 channel A/D converter
- Built-in USART
- SPI and I^2C bus compatibility.

In this project, the microcontroller is operated from a 4 MHz resonator and the voltage to be measured is applied to analog input AN0 of the microcontroller. The analog channels are named AN0 to AN4 and they correspond to the following PORTA names:

Pin	**Channel**
RA0	AN0
RA1	AN1
RA2	AN2
RA3	AN3
RA4	AN4

The default LCD connections also use pins RA0 to RA4. In order to reserve pins RA0 to RA4 for analog channels, the LCD is connected to PORTB as shown below.

PORTB	**LCD pin**
RB0	D4
RB1	D5
RB2	D6
RB3	D7
RB4	E
RB5	RS

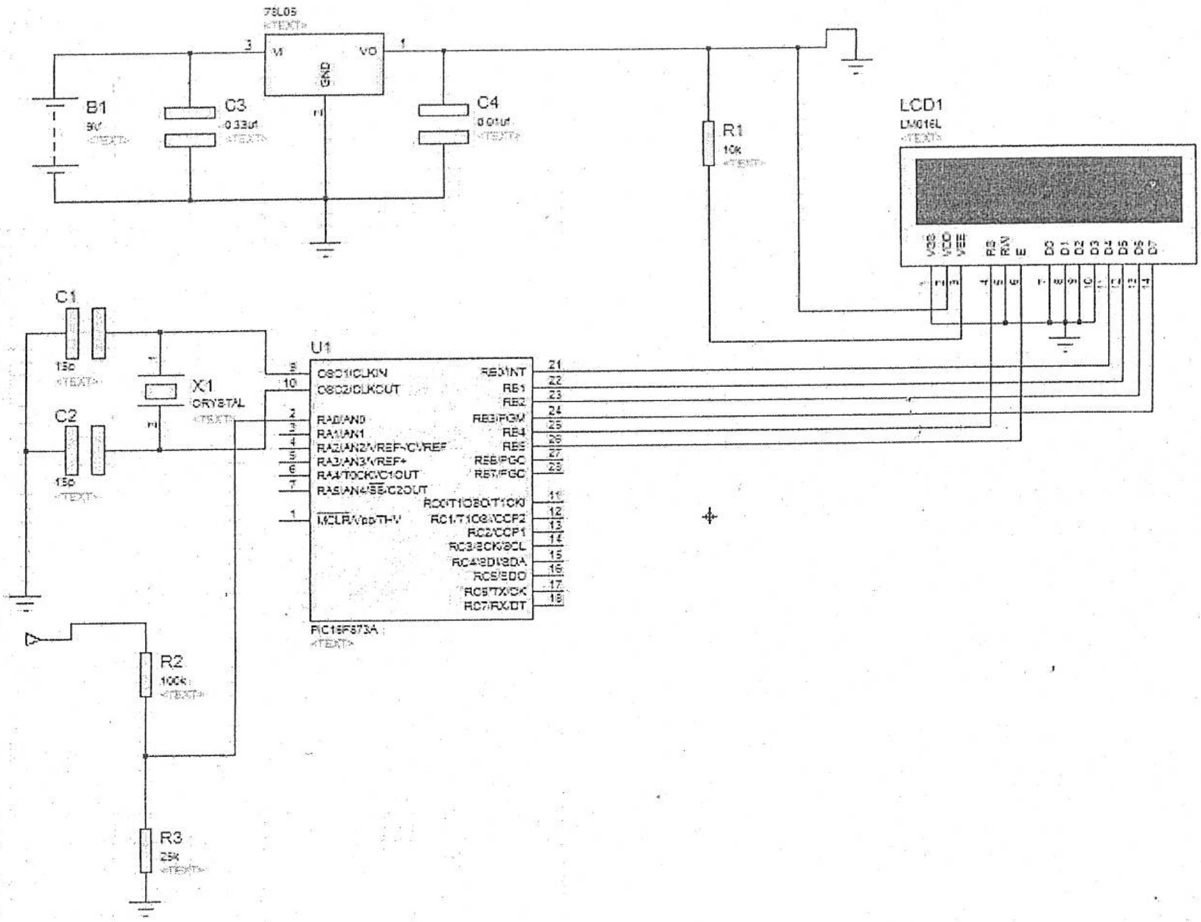


Figure 3.3 Schematics diagram of digital voltmeter circuit using PIC16F873A connected to LCD

Here the constructional details of digital panel voltmeter using PIC16F873A microcontroller is discussed. It can measure voltage between 0V to 25V DC.

3.1.1.1. DESIGN CALCULATIONS AND ANALYSIS

MEASURING VOLTAGE AND DESIGN OF VOLTAGE DIVIDER CIRCUIT

It is important to note again that PIC's ADC can measure 0V to +5V, but here our voltage range is 0V to +25V. Hence we can't feed the input voltage directly to the controller's ADC pins. Instead of feeding directly, input voltage is reduced by a combination of voltage divider resistors.

Maximum allowed drop will be 5V.

$$5 = V_{IN(MAX)} \times R_2 / (R_1 + R_2)$$

Here, $V_{IN(MAX)} = 25V$; and assume $R_2 = 25\ K\Omega$

$$5 = 25 \times 25K / (R_1 + R_2)$$

$$R_1 + R_2 = (25 \times 25K) / 5$$

$$= 125K$$

Hence $R_1 = 125K - R_2 = 125K - 25K = 100K$

* Note: – If you want to increase the input range, let's say 0V to 100V change the above equations accordingly.

CALCULATING ACTUAL (REAL) INPUT VOLTAGE FROM VOLTAGE DIVIDER CIRCUIT

As per our circuit diagram PIC microcontroller reads voltage across 25KΩ resistor. So calculate voltage across 25KΩ resistor by voltage divider rule.

$V_{22} = [V_{IN} / (100K + 25K)] \times 25K$

$V_{22} = (V_{IN} / 125K) \times 25K$

This V_{22} is read by the PIC microcontroller's module

Hence the actual input

$V_{IN} = (V_{22} \times 125K) / 25$

$= 5 \times V_{22}$

MAPPING ADC VALUES TO INPUT VOLTAGE

ADC module of pic microcontroller converts analog signal into binary numbers. PIC16F877A microcontroller have 10 bit ADC. So it converts analog signal to 10 bit digital number which can be back converted into voltage using following calculation in programming of digital voltmeter. Resolution is important to discuss here. Resolution means value for which ADC increment by one. For example pic16f873A microcontroller have 10-bit ADC and it counts binary from 0-1023 for every minimum analog value of input signal. This minimum analog value is called resolution.

ADC increment by one. For example pic16f873A microcontroller have 10-bit ADC and it counts binary from 0-1023 for every minimum analog value of input signal. This minimum analog value is called resolution.

Resolution = (Vrer+ – Vref-) / (1024 -1) ;

In this project we are taking Verf+= 5 volt and Vref- = 0 volt . Hence by using these values in above formula:

resolution = (5 – 0)/ (1023) = 4.8876 mV

- PIC microcontroller ADC is a 10 bit ADC, that means the output of ADC can be vary from 0 to 1023 maximum while input varies from 0 to 5V.
- That is when the input voltage is +5V then ADC value is 1023, when input voltage is 0V ADC value will be 0.
- We have to map 0 → 1023 to 0 → 5; it can be done by multiplying ADC value with a constant K.

$$K = \frac{Maximum\ ADC\ Voltage}{Maximum\ ADC\ value}$$

$$= \frac{5}{1023} = 4.89\ m$$

Hence,

V_{ACTUAL} = ADC Value * 4.89 * 5 milli volt

This will be a five (5) mille volt value

It means for every analog signal of 4.887mV, ADC value increments by one. Liquid crystal display is used to display values of voltage.

3.1.1.2. SOFTWARE FLOW DIAGRAM

The flow diagram of the project is given in Figure 4.3. At the beginning of the program, LCD connections, port directions, and the A/D converter are configured. The voltage to be measured is then converted into digital form, scaled and displayed on the LCD. After 1 s delay this process is repeated.

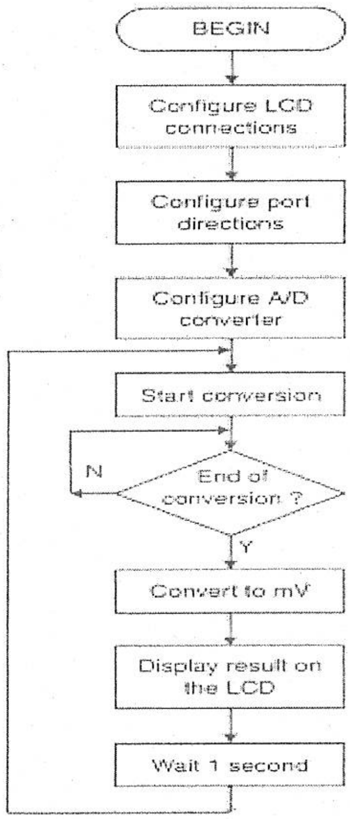


Figure 3.4: Flow diagram of Software programming.

3.1.1.3. SOFTWARE: C PROGRAM

The C program is not complex since LCDs are supported directly using the default LCD connection.

Now to write the program for digital dc voltmeter using pic microcontroller. Code for digital voltmeter is written using Mikro C pro compiler.Voltage measured by ADC module of PIC16F873A microcontroller can be calculated by following programming commands:

voltage = ADC_Read(0); // ADC channel zero stores value in variable voltage

voltage = (voltage * 5 * 5)/ (1024); resolution factor and voltage divider factor

Statement one is used to read ADC value and stores its value in variable voltage and in second statement voltage value is multiplied with resolution factor and voltage divider factor to convert it into input voltage value.

[sociallocker]

```
sbit LCD_RS at RB4_bit;
sbit LCD_EN at RB5_bit;
sbit LCD_D4 at RB0_bit;
sbit LCD_D5 at RB1_bit;
sbit LCD_D6 at RB2_bit;
sbit LCD_D7 at RB3_bit;

sbit LCD_RS_Direction at TRISB4_bit;
sbit LCD_EN_Direction at TRISB5_bit;
sbit LCD_D4_Direction at TRISB0_bit;
sbit LCD_D5_Direction at TRISB1_bit;
sbit LCD_D6_Direction at TRISB2_bit;
sbit LCD_D7_Direction at TRISB3_bit;
int Adread;
float voltage;
```

```
char volt[4];

void main() {


PORTA = 0;

TRISA = 0X01;

PORTB = 0;

TRISB = 0;

LCD_Init();

ADC_Init();

LCD_Cmd(_LCD_CURSOR_OFF);

LCD_Cmd(_LCD_CLEAR);

LCD_Out(1, 1, "Digital voltmeter");

delay_ms(1000);

while (1)

{

voltage = ADC_Read(0);

voltage = (voltage * 5 * 5)/ (1024);

inttostr(voltage,volt); // it converts integer value into string

Lcd_Out(2,1,"Voltage = ");

Lcd_Out(2,11,Ltrim(volt));

Lcd_Out(2,13,"Volt");

}

}
```

[/sociallocker]

This digital voltmeter using pic can read voltage only between 0-25 volt.

3.1.2. DESIGN OF POWER SUPPLY FOR CIRCUIT

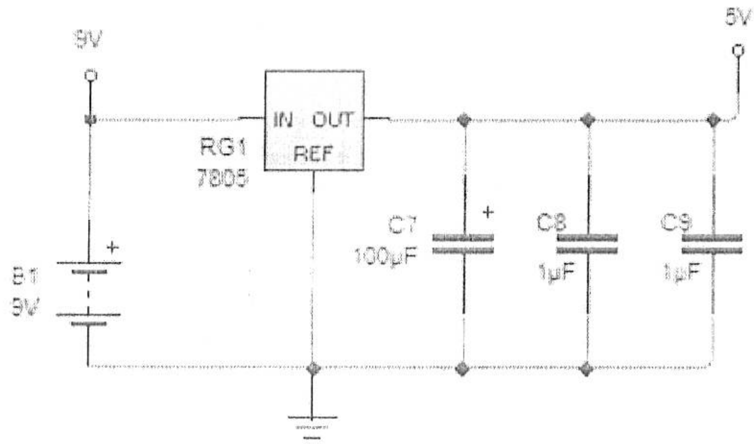


Figure 3.5: Power Supply Circuit

The 5V power supply uses a 78L05 regulator and filter caps to convert the 9V from the battery to 5V for the ISD1110 and the CD4011 circuits.

Figure 3.5 above shows the LM7805 which is connected to a 9V source and provides a constant 5V output. The output is used to supply power to the MCU. The output is also used to power up the voice playback device on the PCB board.

3.1.2.1. DESIGN CALCULATIONS AND ANALYSIS

POWER SUPPLY STAGE FROM AC POWER SUPPLY

The talking voltmeter design uses 5V dc power supply rail. The need for the power supply stage is to provide the voltage and current requirements for the circuit since all electronic components work with D.C voltages. The required dc voltage and current of the power supply for the project is dependent on the component specifications and the nature of the circuit to be powered.

For this project the following power requirements were estimated for the circuit components and stepper motor driven requirements.

POWER SUPPLY REQUIREMENTS.

Supply voltage: DC 5V

Maximum current: 2A

The maximum current is estimated based on the PIC microcontroller used which can operate on a supply voltage from 3-6V DC, specifically 5V (see datasheet in appendices)

ESTIMATION OF CURRENT REQUIREMENT

PIC microcontroller and LCD display = 400mA

Estimated current requirement = 1.1 A

To create some margin for error and tolerance, 1.5A would be used. Hence our power supply must be capable of sourcing 1.5A at 5V.

Figure 3.6 below shows the power supply stage design

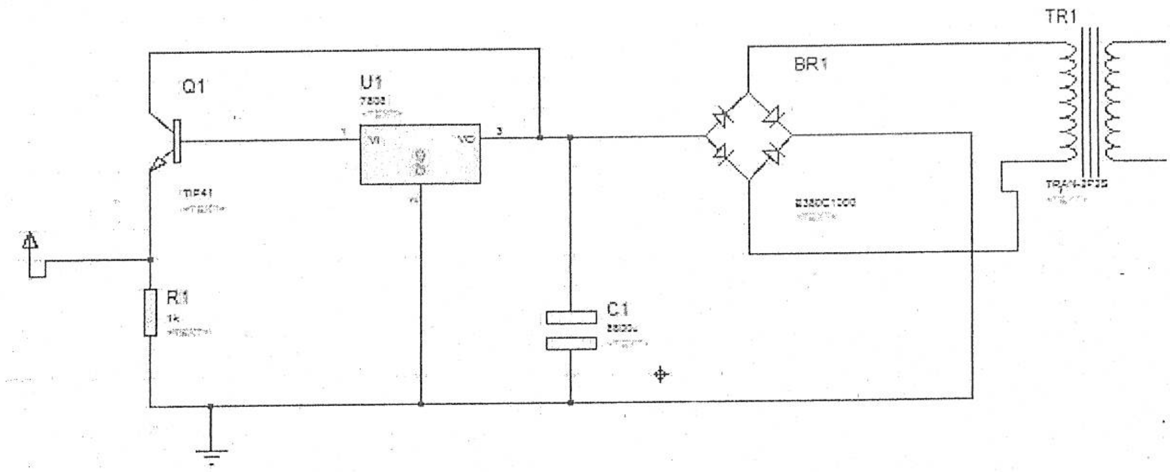


Figure 3.6 Power supply stage design

Figure 3.7 shows the rectified DC waveform (before filtering with a capacitor C1)

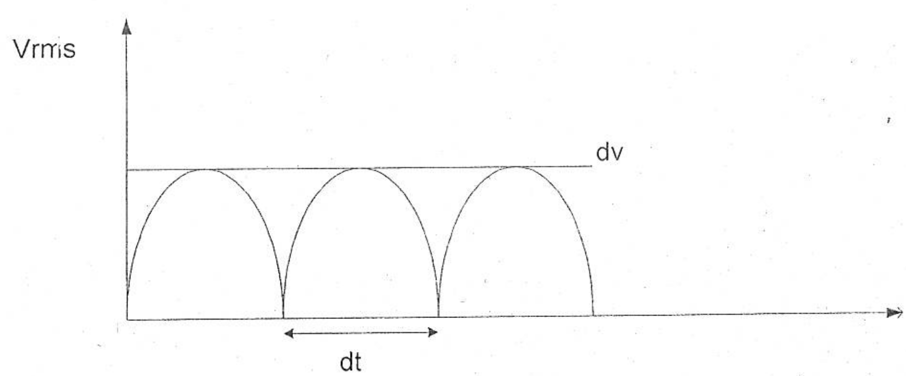


Figure 3.7 Rectified DC waveform

The electric charge, Q = It

Since Q = It

CV= It (since Q = CV) ---------- Equation (3.1)

Where C is the capacitance

V is the voltage

I = current and t = period of one cycle of the AC waveform

From (1) $C = I\frac{t}{V}$

$\Rightarrow C = I\frac{dt}{dV}$ ------------Equation (3.2)

Since C is proportional to the current and also inversely proportional to the ripple gradient of the voltage with time.

The peak unregulated voltage is given by

$V_{PEAK} = V_{RMS} \times \sqrt{2}$ ----------------- Equation (3.3)

Where V_{RMS} is the AC voltage stepped down on the transformer

Hence considering a peak voltage of 12V dc, from Equation (3.3)

$V_{RMS} = \frac{12V}{\sqrt{2}} = 8.48 \approx 9V$ AC

This implies a step down transformer of 9V at 1.5A

From (2) $C = I\frac{dt}{dV}$

I = 1.5A as required from PSU requirement for design

dt = 0.01s (this is the time duration of the duty cycle of half the waveform)

dv = ripple factor

which is approximately 20% of the peak voltage from (2) $C = 1.5A \times \frac{0.01}{2.4V}$

$= 6250$ UF

$= 6800$ Uf preferred value

Hence the value of C1 in the Figure 3.6 is 6800uf

3.1.3. DESIGN OF THE VOICE PLAYBACK CIRCUIT

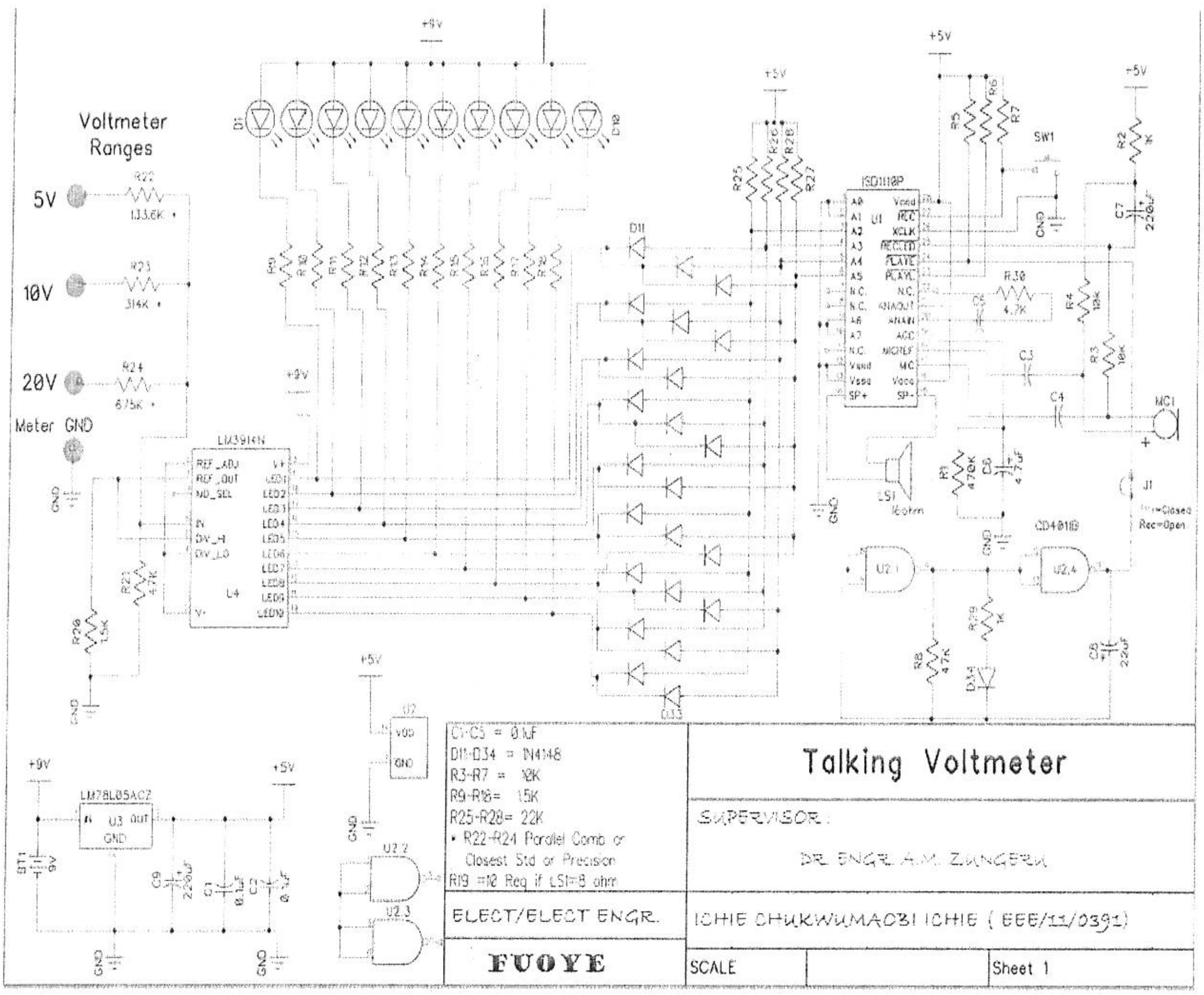


Figure 3.8: voice playback circuit

Circuit was constructed as in the figure above. The MCU (PIC16F873A) circuit was constructed separately and the circuit for voice playback was constructed separately. This is to ensure that the MCU can be interfaced with any circuit by manipulating the pins.

This was done to ensure that the voice playback circuit are operated separately in case there are any replacements or modification which might be involved in the near future.

3.1.3.1 VOICE RECORDER IC THEORY AND OPERATION

The ISD1110P is a voice recorder that can record up to 10 seconds of audio. It is perfect for this application. Since we have a one of ten voltmeter output for the LED, each output through the address encoder can select one of ten internal locations in the voice chip. Each of these locations can therefore hold 1 second of sound. Enough to record a digit such as "Seven", or alternately other information such as "Warning". If you are quick, you can even record a very short phrase such as "Voltage High". Once recorded, the chip will store the recording for up to 100 years, so it might even be useful for a very long time. You can also change the recording as you choose therefore not feeling locked into one application. Recording is initiated by removing the shorting jumper on J1, and then pressing SW1. This pulls the REC input low. To fill the ten locations you will adjust an input voltage to the meter to get the LED lit, then record that value, adjust the input voltage until the next LED that you want recorded is lit, then record that value and so on. It is not necessary to record every location, depending on your application. It is important that you release SW1 before one second, otherwise you will automatically go into the next recording position. It takes a bit of practice to get it right, so if you accidentally erase another number just do it over. When recording is completed, the jumper at J1 is reconnected to put the chip in playback mode and it is then ready for use. The clock circuit will initiate the playback, not the LED lighting up, keep this in mind when the input voltage changes quickly. Values continuously changing more quickly than once per second are not appropriate for this type of meter.

The clock can be slowed down as desired, but cannot be sped up beyond the output time of the recorded message. The ISD1110P is designed to drive a 16 ohm speaker directly. If a lower impedance speaker, a resistance at R19 is used to compensate. The most common would be to use a 10 ohm resistor to allow use of an 8 ohm speaker. For most uses this will be loud enough, but an external amplifier can be used, if the measurement needs to be heard in noisy locations. This circuit uses an on board electret condenser microphone. R4 supplies the voltage that these mics need to function.

3.1.4. LCD DISPLAY CIRCUIT (16X2)

As for this circuit it is directly connected to the PORT D and PORT C of the PIC. The LCD panel's Enable and Register Select is connected to the Control Port. The Control Port is an open collector / open drain output. The Data bus is not set into reverse direction which means the data bus pins are directly connected to the PORT D, Therefore the R/W line of the LCD panel is hard wired into write mode, this will cause no bus conflicts on the data lines. As a result the user cannot read back the LCD's internal Busy Flag which tell the user if the LCD has accepted and finished processing the last instruction. This problem is overcome by inserting known delays into the program. Hence the display LCD portrays the character of the output.

3.1.5. DESIGN OF LM3914 DOT/BAR DISPLAY DRIVER

The voltmeter section is also based on the LM3914 Dot/Bar display driver wired in the dot mode. It accepts an analog voltage between 0 and 1.3V and creates a linear 1 of 10 output corresponding to the actual value of the input. It can drive LEDs directly but in our application requires resistors to each LED to provide the necessary voltage levels to the digital encoder circuit which will provide a digital address to the audio recorder chip.

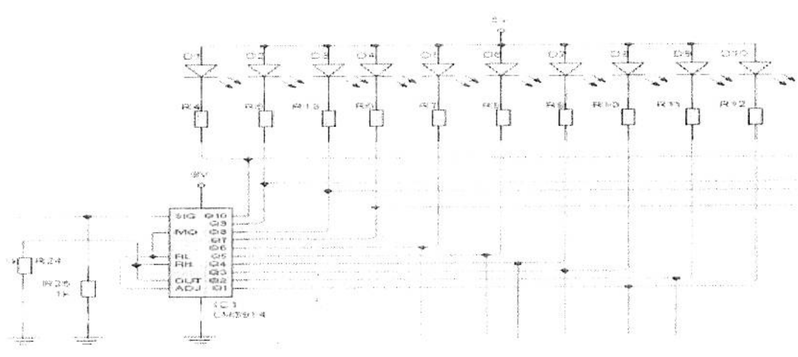


Figure 3.9: LM3914 Dot/Bar Display Driver circuit.

3.1.6. DESIGN OF CLOCK CIRCUIT

Theory: The clock circuit provides a pulse to the voice recorder chip to tell it when to speak. As designed the clock will trigger the speech at about once per second. This can be slowed down by increasing R8 or C8. U2 is a 4011 quad NAND gate with two of the gates wired in a common oscillator configuration which will normally produce a roughly 50% duty cycle square wave. In this circuit R29 and D34 have been added to shorten the OFF pulse length to increase the duty cycle to about 90%. This results in frequency of approximately f = 1/(R*C) the narrow negative (OFF) pulse is important to trigger the ISD1110 in a manner that the trigger pulse ends well before the end of the recorded speech.

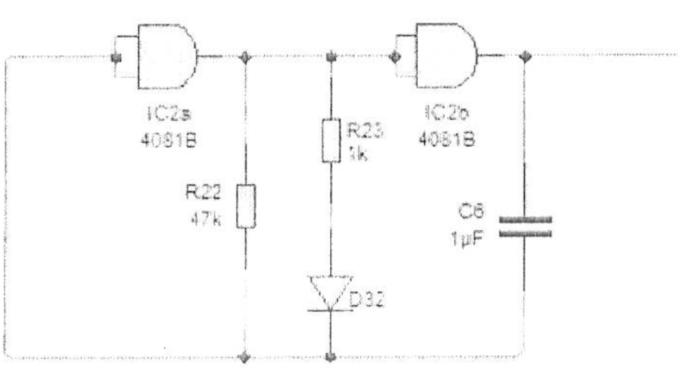


Figure 3.10: Clock circuit

3.1.7. DIGITAL ADDRESS ENCODER

Theory: The voice chip will have its memory divided into ten locations, each of which stores the recorded audio then plays back when the corresponding voltage is reached. The voltmeter that you built produces an output known as "active low - one of ten" meaning that at any given voltage within its range, one of ten possible outputs will be pulled low. The voice chip on the other hand will need an active high binary address using four input lines weighted (or value of) 1,2,4, & 8. For example to say "One" or the word in the first locations, line 1 needs to be high while 2,4,8 are pulled low. Or to say "Five" or the word in the fifth location line 1 and 4 (1+4=5) need to be high while the 2 and 8 are pulled low. A diode encoder is used to do this and is made up of diodes D11

- D33. For each of the ten outputs from the voltmeter section, a group of diodes is activated when that output occurs. So when LED 1 (1 volt) lights, the corresponding 3914 line is LOW, and D11, 12, 13 "see" this low and pull the 2,4,8 lines low so the chip is being addressed at location 1. If you study the PC card and diodes you should be able to discern how each of the addresses are achieved. When a diode is not actively pulling a line low, there needs to be some way to make sure the line is high, and that is the job of the 22K resistors R25 - R28.

The listed values are expected outputs as read by a meter or logic probe on the left end of R25, 26, 27 & 28. A High should be about 5V and Low should be less than 2V

LED ON	**R25 (1)**	**R26(2)**	**R27(4)**	**R28(8)**
1	High	Low	Low	Low
2	Low	High	Low	Low
3	High	High	Low	Low
4	Low	Low	High	Low
5	High	Low	High	Low
6	Low	High	High	Low
7	High	High	High	Low
8	Low	Low	Low	High
9	High	Low	Low	High
10	Low	High	Low	High

Table 3.1: Digital Encoder Output Table.

CHAPTER FOUR

CONSTRUCTION AND TESTING

4.1 TESTING & MEASUREMENTS

The following were used for the testing of the project both during the construction and implementation and also for analysis to compare results of the voltmeter output and the mentioned equipment.

There include

BENCH POWER SUPPLY:

This was used to supply voltage to the various stages of the circuit during the breadboard test before the power supply in the project was soldered. Also, during the soldering of the project the power supply was still used to test various stages before they were finally soldered.

DIGITAL STORAGE OSCILLOSCOPE:

This was used to supply voltage to the various stages of the circuit during the breadboard test before the power supply in the project was soldered. Also, during the soldering of the project the power supply was still used to test various stages before they were finally soldered.

DIGITAL MULTIMETER:

The digital multimeter basically measures voltage, resistance, continuity and current. The process of implementation of the design on the board required the measurement of parameters like voltage, continuity, and resistance values of the components

4.2. RESULTS

These are the results of obtained from testing the various voltmeter sections with the digital storage oscilloscope and a bench voltage supply. The various sections tested are the

1. LM3914 Dot graph analog voltage voltmeter
2. PIC16F873A and LCD voltage digital voltage display
3. ISD1110P speech section

4.2.1 RESULTS OF LM3914 VOLTMETER SECTION

These sections constitutes of the LM3914 and the ten LED outputs, these section was tested by connecting the inputs to a bench voltage power supply and checking the corresponding outputs of the LEDs with the inputted values. The following results were obtained

VOLTAGE SUPPLY	LED (ON)	VOLTAGE SUPPLY	LED(ON)
0.35V	LED (1)	5.49V	LED (5)
0.77V	LED (1)	5.71V	LED (6)
1.00V	LED (1)	6.03V	LED (6)
1.23V	LED (1)	6.32V	LED (6)
1.63V	LED (2)	6.89V	LED (7)
2.07V	LED (2)	7.04V	LED (7)
2.48V	LED (2)	7.41V	LED (7)
2.85V	LED (3)	7.88V	LED (8)
3.03V	LED (3)	8.00V	LED (8)
3.33V	LED (3)	8.10V	LED (8)
3.61V	LED (4)	8.96V	LED (9)
4.05V	LED (4)	9.03V	LED (9)
4.37V	LED (4)	9.32V	LED (9)
4.80V	LED (5)	9.64V	LED (10)
5.07V	LED (5)	10.00V	LED (10)

Table 4.1: RESULTS OF LM3914 VOLTMETER SECTION

All other input voltage levels above ten volts (10V) results still on the LED(10) being ON.

4.2.2. RESULT OF PICI6F873A TO LCD SECTION

This section involves a digital output display of voltage supplied into the PIC16F873A by a digital storage oscilloscope and displayed by the LCD. The displayed voltage is analyzed with reference to the input voltage and checking the error within.

Table 4.2: RESULT OF PICI6F873A TO LCD SECTION

PIC – LCD OUTPUT	OSCILLOSCOPE (hundredth)	%ERROR	PIC – LCD OUTPUT	OSCILLOSCOPE (hundredth)	%ERROR
0.27V	0.25V	8%	10V	10.01V	0.099%
1.04V	1V	4%	11V	10.98V	0.182%
1.99V	2V	0.5%	12V	12.01V	0.083%
2.5V	2.5V	0%	13V	12.99V	0.0769%
2.9V	3V	1%	14V	14V	0%
4.0V	4V	0%	15V	15V	0%
4.7V	4.75V	0.42%	16V	16.01V	0.625%
5.0V	5V	0%	17V	17V	0%
5.8V	5.84V	0.17%	18V	17.99V	0.056%
6V	6.01V	0.167%	19.6V	19.58V	0.102%
6.5V	6.51V	0.153%	20.0V	20V	0%
7.04V	7.04V	0%	21.6V	21.61V	0.046%
7.9V	8V	0.51%	22.1V	21.9V	0.502%
8.1V	8.13V	0.25%	23V	23V	0%
8.8V	8.83V	0.34%	24V	24V	0%
9.3V	9.3V	0%	24.5V	24.51V	0.041%
9.9V	9.87V	0.20%	25V	25V	0%

This voltage segment has a maximum digital voltage display of 25V due to the multiplier resistor used, therefore all voltage inputs above 25V still results in a display of 25.0 ADC on the LCD.

4.2.3. RESULT OF THE VOICE PLAYBACK VOLTMETER SECTION

This is the talking segment of the talking voltmeter where there is a spoken value for each voltage value inputted. The ISD1110P can only take ten seconds of storage therefore we have only ten spoken values for the range of input inserted into the talking voltmeter.

Using the same values for the LM3914 section, the following results were obtained.

Table 4.3: RESULT OF THE VOICE PLAYBACK VOLTMETER SECTION

VOLTAGE SUPPLY	SPOKEN VALUE	VOLTAGE SUPPLY	SPOKEN VALUE
0.35V	N/A	5.49V	FIVE
0.77V	N/A	5.71V	FIVE
1.00V	N/A	6.03V	SIX
1.23V	N/A	6.32V	SIX
1.63V	ONE	6.89V	SIX
2.07V	TWO	7.04V	SEVEN
2.48V	TWO	7.41V	SEVEN
2.85V	TWO	7.88V	SEVEN
3.03V	THREE	8.00V	EIGHT
3.33V	THREE	8.10V	EIGHT
3.61V	THREE	8.96V	EIGHT
4.05V	FOUR	9.03V	NINE
4.37V	FOUR	9.32V	NINE
4.80V	FOUR	9.64V	NINE
5.07V	FIVE	10.00V	TEN

4.3 ANALYSIS OF RESULTS

4.3.1 ANALYSIS OF RESULT OF LM3914 VOLTMETER SECTION

After the analysis of the results obtained after comparing with the bench power supply it is observed that the LM3914 voltmeter section responds to changes in voltages once the value inputted is above the average between two successive values the voltage changes. i.e anything above the 0.5v volt results in movement to the next voltage level via LED display. Also any voltage inputs results into the lighting of the LED (ONE) irrespective of the value of voltage input as long as it is less than 1.5V.

Finally all voltage values above ten volts (10V) continues to trigger a voltage display of then LED (10) i.e. the tenth LED. Therefore once the input value is above 10V, the tenth LED remains on. This is due to the LM3914 having only ten analog outputs.

4.3.2. ANALYSIS OF THE RESULTS FROM PICI6F873A TO LCD SECTION

From the table of voltages measured by our voltmeter versus the same voltages measured by the oscilloscope it is observed that our voltmeter was very accurate to the hundredth value. It is observed that the error is slightly bigger for earlier values because they're more vulnerable to noise. All later values have minimal error margins and also the rate of response to changes to inputted values is instant.

The display of 25V even at higher input value is due to the multiplier resistors used on the PIC16F873A which normally has just 5V as its maximum acceptable input.

Any attempt to still increase the voltage range by varying the multiplier resistors results in much more bigger errors in the earlier values between 0V – 5V.

4.3.3 ANALYSIS OF RESULT OF THE VOICE PLAYBACK VOLTMETER SECTION

It is observed that there is no voice output for values below 1.55V but once there is a voice output for the 1V voltage level, all voltage levels give an instant voltage playback voice output. The voice playback is gotten from the ISD1110P which has just 10 seconds available, thus providing only ten voltage level. Any voltage level above ten volts (10V) still results in a voice output of ten.

4.4. PROJECT CONSTRUCTION

The construction of the project was done in two different stages.

The soldering of the circuits to the boards and then the coupling of the entire project to the casing.

The soldering of the project was done on a Vero-board, and was soldered on one Vero-board because of the complexity of the circuit.

The Vero-board contains the power supply, LM3914, PIC, and ISD1110P voltmeter stages.

Figure 4.1 below shows the soldering of components being arranged on the Vero-board.

Figure 4.1 components being laid on Vero-board

4.4.1. CASING AND BOXING

The second phase of the project construction is the casing of the project. This project was coupled to a plastic casing. Figure 4.2 below, shows the Isometric view of the casing used for the project.

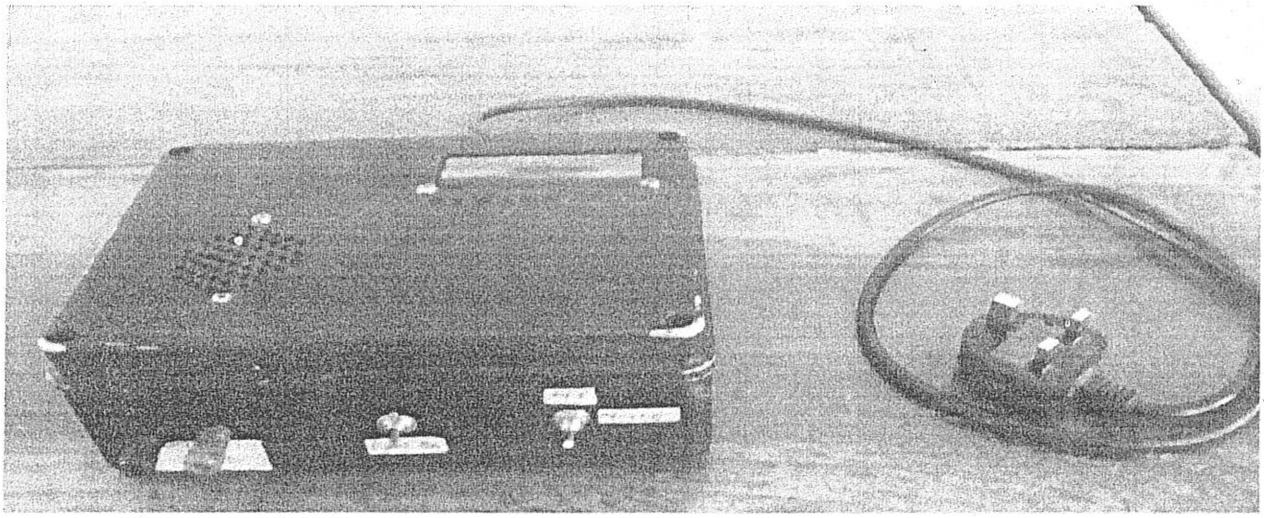


Figure 4.2 isometric view of cased job

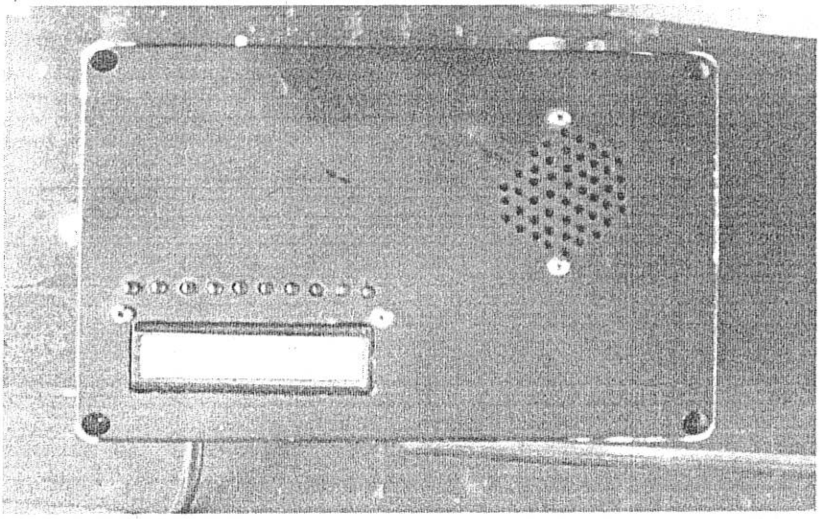


Figure 4.3 Top view of the Talking voltmeter

4.5. OBSERVATION AND DISCUSSION

Throughout the entire duration of this project, three methods were used obtain voltage outputs with one of them to implement the voice generation and these are:

1. LM3914 Dot graph analog voltage voltmeter
2. PIC16F873A and LCD voltage digital voltage display
3. ISD1110P speech section

Each having a high speed of execution, good resolutions and very little errors.

4.5.1 SAFETY

Great care was taken to see that our practices and final project met the highest standards for safety. Every time we had to solder something onto the board, safety goggles were worn, also making sure the iron is heated appropriately and turned off when not needed. We would also always ground ourselves when handling any circuitry. As can be seen from the final product, our soldering and wiring was very neat and properly laid out. This project doesn't pose a significant harm to anyone else while in operation due to the low voltage input.

4.5.2. INTERFERENCE

We did not experience much interference when the Handy Lab device (talking voltmeter) was under voltage measurement operation.

4.5.3. UNIVERSAL USABILITY

This device is usable by any person who actively works in the lab. Since it measures only low voltages, it does not pose much harm. Persons with special needs who can operate simple lab voltmeters can use this device - and in fact get voice output. So it is even advantageous for some person to utilize this device instead of standard lab equipment.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This project is majorly constituted of the analog voltmeter (LM3914), power supply, clock pulse generator (CD 4011), digital address encoder (diodes 1N4148), audio recorder (ISD1110P), PIC16F873A, LCD Display and the speaker. All producing three different voltmeters (voltage output with reference to input voltage).The three voltmeters are: The LM3914 analog LED display of voltage ranges, the PIC to LCD digital voltage display, and the ISD1110P Voice output display.

The production of voice output by the ISD1110P voice playback chip through the speaker is the ultimate goal of the talking voltmeter project as the other voltage output products are add-ons. The project has been a great experiences embracing both theoretical and practical knowledges.

The project could be used in various scenarios avoiding the normal lab voltmeters

- For people without sight capability, to be part of the laboratory process, knowing change in voltage levels
- Easing work of lab students, by preventing multi-tasking, i.e checking the voltage by sight and still holding the probes; thus reducing errors
- Could be used with non-calibrated bench voltage supply to know exact value of the voltage output through the LCD display

The final project was design, implementation and tested in the electrical electronics laboratory of Federal University Oye-Ekiti.

5.2 RECOMMENDATIONS

Upon the completion of our project The Talking Voltmeter, It is realized that in the years to come there may be another chance for improvement with the current technology rocketing in time in The Talking Voltmeter. The suggested improvement methods are listed as below:

1. A PIC could be used instead of the LM3914 for the ADC, thus eliminating a much bulky circuit.

2. If a PIC which a larger voltage range can be used or a PIC which when a multiplier circuit that would not result in a very large noise for initial voltage ranges could be used.

3.For the voice playback IC the ISD4003 could be used although much expensive and very rare to source locally asides importation like the ISD1110P, this is because the ISD4003 has a voice recording and playback time of about four to eight minutes and therefore could be partition to about 480 seconds at maximum, thus increasing the voice output capability.

4. If the ISD4003 is used therefore, a PIC would be required for the ADC and the digital addressing. Such PIC could be the PIC16F877A having 28 pins.

This project can easily be commercialized for use in labs. It is useful for any electrical engineer, as the talking capability comes in handy when debugging a complicated circuit and not being able to look at the display.

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APPENDIX I PROGRAM CODE

[sociallocker]

```
sbit LCD_RS at RB4_bit;
sbit LCD_EN at RB5_bit;
sbit LCD_D4 at RB0_bit;
sbit LCD_D5 at RB1_bit;
sbit LCD_D6 at RB2_bit;
sbit LCD_D7 at RB3_bit;

sbit LCD_RS_Direction at TRISB4_bit;
sbit LCD_EN_Direction at TRISB5_bit;
sbit LCD_D4_Direction at TRISB0_bit;
sbit LCD_D5_Direction at TRISB1_bit;
sbit LCD_D6_Direction at TRISB2_bit;
sbit LCD_D7_Direction at TRISB3_bit;
int Adread;
float voltage;
char volt[4];
void main() {

PORTA = 0;
TRISA = 0X01;
```

```
PORTB = 0;
TRISB = 0;
LCD_Init();
ADC_Init();
LCD_Cmd(_LCD_CURSOR_OFF);
LCD_Cmd(_LCD_CLEAR);
LCD_Out(1, 1, "Digital voltmeter");
delay_ms(1000);
while (1)
{
voltage = ADC_Read(0);
voltage = (voltage * 5 * 5)/ (1024);
inttostr(voltage,volt); // it converts integer value into string
Lcd_Out(2,1,"Voltage = ");
Lcd_Out(2,11,Ltrim(volt));
Lcd_Out(2,13,"Volt");
}
}
```

[/sociallocker]

APPENDIX II: COST AND PROJECT COMPONENTS.

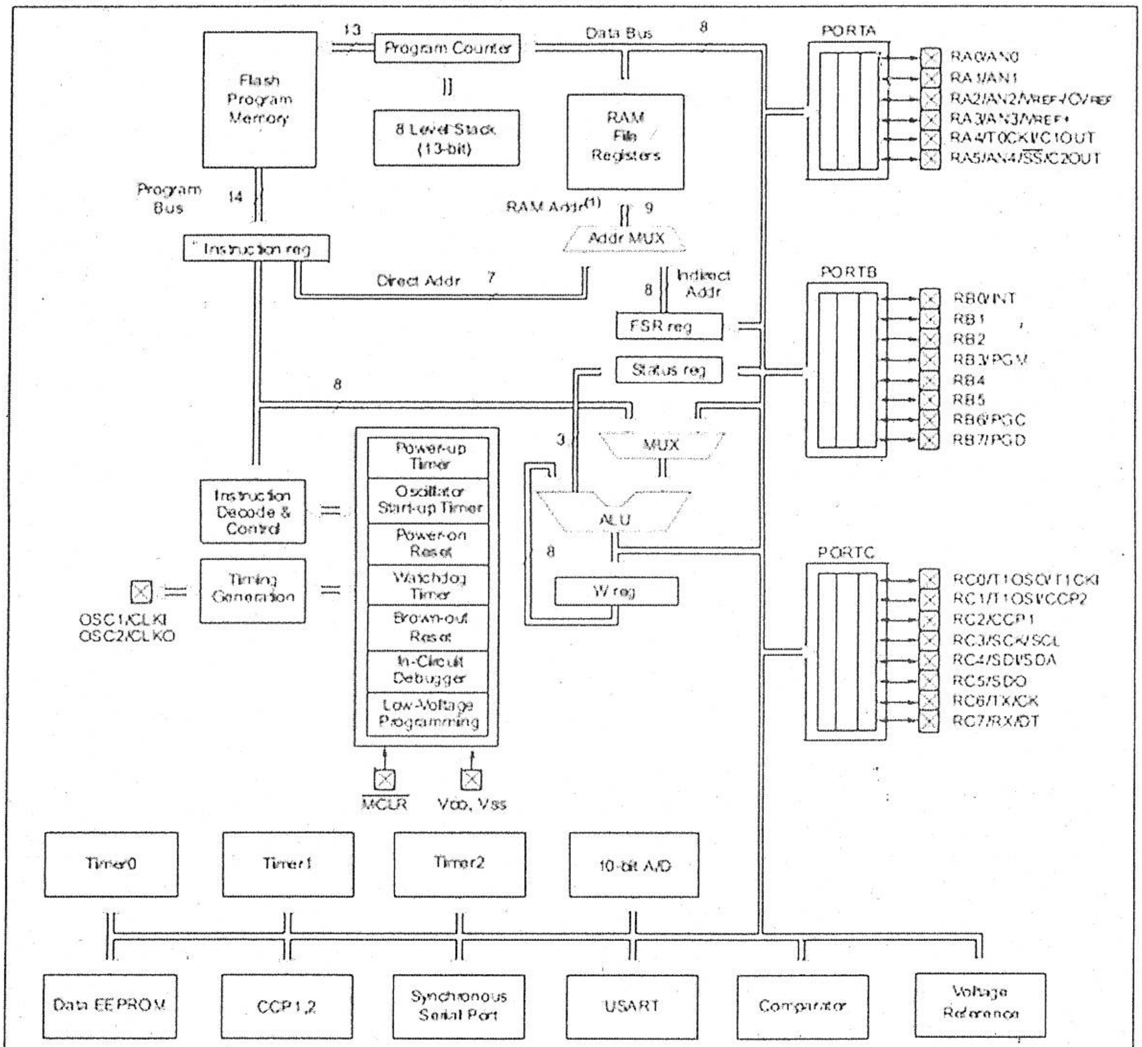
Qty.	Description	Cost (Naira)	Total (Naira)
1	IC, NSC, LM3914N, DIP-18	1000	1000
10	CAPACITOR, 0.1uF,50V,20%	50	500
10	CAPACITOR, 4.7uF,50V,20%,85C	50	500
30	DIODE,SWITCH,1N4148	50	1500
10	SOCKET,IC,18PIN,SOLDERTAIL	90	90
10	SOCKET,IC,28PIN,.600",TIN	90	90
1	IC,78L05,+5V,TO-92	120	120
10	SOCKET	80	80
1	IC,ISD1110P	2500	2500
10	LED,RED,643NM,T-1 3/4	10	100
1	SWITCH,PB,TACT,SPST,OFF-(ON)	90	90
1	HEADER,.1"ST MALE,1RW,8PIN	60	60
10	SOCKET,IC,14PIN,SOLDERTAIL	70	70
1	MICROPHONE	200	200
1	BATTERY SNAP	60	60
2	ALLIGATOR CLIP	130	130
10	CAPACITOR, 22uF,50V	50	500
10	CAPACITOR, 220uF,16V	50	500
10	RESISTOR, 22K OHM,1/4 WATT,5%,	10	100
10	RESISTOR, 47K OHM,1/4 WATT,5%	10	100
10	RESISTOR, 330K OHM,1/4 WATT,5%	10	100
10	RESISTOR, 1.2M OHM,1/4 WATT,5%,	10	100
10	RESISTOR, 6.8M OHM,1/4 WATT,5%	10	100
1	NAND GATE	100	100
1	Speaker, 3.0" 16Ω	450	450
10	RESISTOR, 1K OHM,1/4 WATT,5%	10	100
10	RESISTOR, 10K OHM,1/4 WATT,5%	10	100
10	RESISTOR, 4.7K OHM,1/4 WATT,5%	10	100
10	RESISTOR, 470K OHM,1/4 WATT,5%	10	100
10	RESISTOR, 680K OHM,1/4 WATT,5%	10	100
20	RESISTOR, 1.5K OHM,1/4 WATT,5%	10	200
10	RESISTOR, 150K OHM,1/4 WATT,5%	10	10

1	PIC16F873A	1500	1500
1	LCD(16X2)	800	800
1	TRANSFORMER 220V/15V, 2A	800	800
1	4MHZ CRYSTAL	700	700
1	VERO BOARD	200	200
1	CASING	3500	3500
2	SOLDERING LEAD	100	200
	TOTAL (Naira)		17550
	SHIPPING OF ISD1110P	18000	18000
	TOTAL (Naira)		35550

APPENDIX III: PIC16F73A BLOCK DIAGRAM FROM DATASHEET

PIC16F87XA

FIGURE 1-1: PIC16F873A/876A BLOCK DIAGRAM



Device	Program Flash	Data Memory	Data EEPROM
PIC16F873A	4K words	192 Bytes	128 Bytes
PIC16F876A	8K words	368 Bytes	256 Bytes

Note 1: Higher order bits are from the Status register.