DESIGN, CONSTRUCTION AND TESTING OF A DIGITAL WEIGHING MACHINE USING A PROGRAMMABLE INTEGRATED CIRCUIT

BY

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NOVEMBER, 2008.

DECLARATION

I hereby declare that this work was carried out by me. To the best of my knowledge and belief, this work has never been submitted either in Federal University of Technology Minna, or any other institution for the award of any degree of certificate.

Ibrahim Moses

17/11/08
Date

CERTIFICATION

This is to certify that this project titled "Digital weighing machine using programmable integrated circuit" was carried out by IBRAHIM MOSES. It satisfies the regulations/standards governing the award of the degree of bachelor of Engineering in Electrical and computer engineering, School of Engineering and Engineering Technology of Federal University of Technology, Minna, Niger state.

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DEDICATION

This work is dedicated to GOD Almighty for his loving kindness over my life through out my stay in school. My lovely parents Mr. and Mrs. M.K. Ibrahim for their financial, moral and emotional support love you guys.

ACKNOWLEDGEMENT

The history of man cannot be made from nature apart from his surrounding and people around him. Certainly there some people that my history cannot be told without them being mentioned.

It is on the note that I give thanks to the Almighty GOD who has been faithful in reserving my life to witness this day.

I also acknowledge the great contribution done by my supervisor, Mr. J. Ajiboye for his effort in overseeing the work and making valuable suggestion towards the completion of this work. I must confess that it was a rare privilege to be his student.

This project was sincerely made possible through the unending support of my parents Mr. and Mrs. M.K.Ibrahim, who had laboured so much to see that I succeeded even at times when it was not convenient for them. I also say a big thanks to my guardian Mr. and Mrs. Egbita may God reward you abundantly. Not forgetting my late uncle and aunty Mr. and Mrs. Agbo. It's really unfortunate that you both weren't alive to witness this day but God knows best. MISS YOU.

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ABSTRACT

This project work provides a digital weighing machine the ability to display a weighed object or device when properly placed on the load cell. The load cell senses the force acting on it and sends its output which is in millivolt to an instrumentation amplifier for amplification. The analog voltage amplified goes to the ADC to be converted for use by the microcontroller which gives you the desired unit you want. After that, it displays the measured quantity on the LCD.

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CHAPTER ONE

1.1 INTRODUCTION

From the earliest times, the concept of measurement has been a necessity for man. This has led to continual advances in the field of measurement and instrumentation.

Measurement is an act or a result of quantitative comparison between a predefined standard and an unknown magnitude [1]. These standards include the meter, kilogram, liter, etc.

Scale or balance is a mechanical or electronic device used to measure the mass of an object or quantity of some substance using its weight.

. Weight is the downward force resulting from the gravitational attraction of the earth. This is given as mass (m) multiplied by gravity

Measuring instruments are essential components of a control system.Measurement is therefore necessary for evaluating the performance of a system or studying the response of such system to a particular input function. It also applies in the study of some basic laws of nature [1]. Weight scales are a necessity for monitoring purposes in homes ad fitness centers. They are also found in hospitals for weighing poatients and new born babies.

The control of weight calls for constant measurement as a number of diseases such as obesity, strokes, heart attacks, coronary heart disease and other cardiovascular diseases have been discovered to be related to excessive weight [2]. On the other hand, issues on malnutrition and under weight also give credence to the need of measurement scales. Since the weight of a man is an indicator to the state of his health.

It is worthy of note that the numerous advances in the medical and health fields can be attributed to electrical and electronic inputs.

1.2 THE ADVANTAGE OF DIGITAL SYSTEMS OVER ANALOGUE SYSTEMS

A digital system at its lowest level is a network of wires and mechanical parts whose voltages and positions convey coded information. These codes are numbers which are numbers which are represented by circuits that distinguish various discrete electrical signals on wires inside the machine basically as 0's and 1's corresponding to the binary number system [2]. Analogue systems on the other hand have signals that vary continuously with the input.

Digital systems unlike analogue systems are free from scaling requirement and are moiré convenient to operate. They possess higher sensitivity, speed and accuracy. They respond dynamically to changes in the input and also possess freedom from operator errors and error due to parallax. Analogue signals can be converted to digital signals using Analogue to Digital Converters (ADCs).

1.3 AIMS AND OBJECTIVES

Applying the advantages of digital electronics, this project is aimed at designing and construction a weight scale whose weight measure would be given as a digital output. This project aims at a low cost implication of the design while maintaining portability. Giving a much better resolution than an analogue weighing machine, it is also a major aim in this project. As accuracy and sensitivity is the measure of a scales quality, precision remains a primary objective of this work.

1.4 METHODOLOGY

The circuit presented in my project work explains the principle and methods uses in weighing an object or device. The load cell places a very vital role in my project work. It has a maximum range of 100Kg. When load its applied to it, it senses the load on it. A multivolt is produced as the output and there is need for amplification by an instrumentation amplifier for the ADC to read what's coming into it in volts.

The microcontroller is programmed in such a way it interprets what's in the ADC to desire weighing units, either in kg, tones, or pounds etc. depending on the choice of the programmer. In my case kilogram was used as my weighing unit, using basic as my programme implementation the weighing device or object is display on LCD for an individual to see.

1.5 BLOCK DIAGRAM

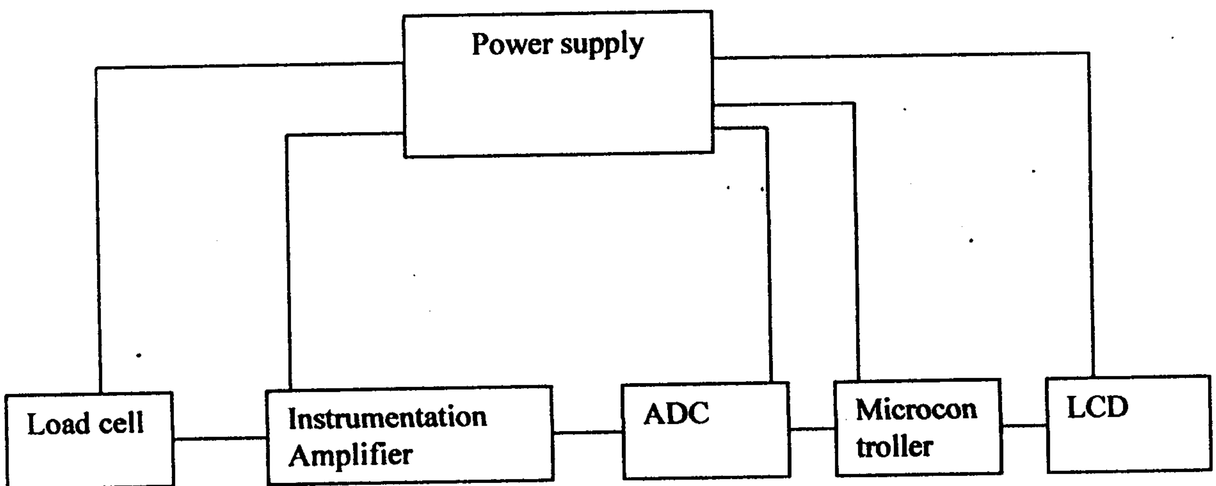


Fig 1.1: Block Diagram of a Digital Weight Machine

1.6 PROJECT LAYOUT.

CHAPTER ONE gives a brief introduction into measurement. It talks about the aims and objective of a measuring device. CHAPTER TWO talked about the literature review and history of a digital weighing machine. CHAPTER THREE explained the system analysis and design of a weighing machine. CHAPTER FOUR talk about my construction and testing. CHAPTER FIVE was about my conclusions and recommendation on my project work.

CHAPTER TWO

2.1 LITERATURE REVIEW

The balance (derived from the Latin word "bilanx" meaning two plates) referred to as scales in the modern times, was used first by the ancient Egyptians and Babylonians at about 5000 BC [3]. It consists of a simple beam pivoted at its center with standard weight in open pan and the unknown weight in the other. The Romans improved on this when at the pivoted point they fixed a triangle section to the beam increasing its accuracy and sensibility. This was called the equal arm balance. It had two pans suspended from a light weight rigid beam pivoted at center on an agate knife edge resisting on an agate plate at the top of the central column of the balance. The two pans hung from stirrups supported by the agate plate. A pointer attached to the beam centre extended down to a scale at the bottom of the column to indicate when the beam was horizontal i.e. the two pans were equally loaded [4].

A further improvement brought about the single pan balance having one pan and a fixed counter weight at the other end. This further gave rise to the steelyards used by the Danish and the Romans about 2000 years ago.

However, the chemist Joseph Black (1728-1799) of scotch decent was of Scottish decent was credited for the first use of a balance. Spring scales came as a further development. They operate on the principle that when a helix is subjected to tension the amount of elongation increases proportionally with the increase in the force of tension. The spring balance includes a helical spring suspended from a fixed point carrying a weighing pan. Improvements brought in the weighing pan which was patented in 1831 Thaddens Fair Banks of St John Bury Vt [4].

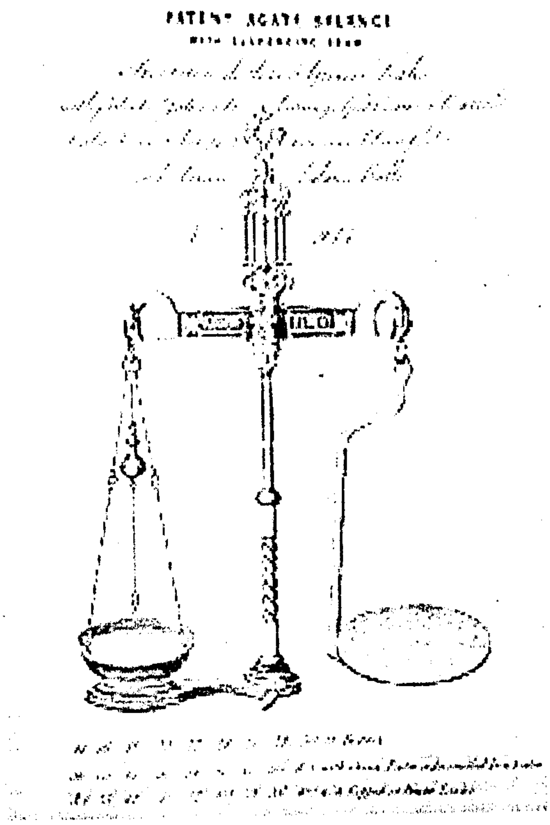


Fig 2.1: Patent Agate Balance

Every human being on our planet is affected by weights and measures in some way. From the moment we are born and throughout our daily lives, weighing and measuring are an important and often vital part of our existence. Our bodies, the food we eat and all the products we use as an integral part of modern living have all been weighed and measured at some stage in their development.

Weights and measures are undoubtedly one of man's greatest and most important inventions, ranking alongside the wheel in the evolution of civilization. Commerce would not have progressed beyond the barter system without the invention of a system of weights and measures.

There are three elements to the weighing story and each evolved over the 6,000 years of its history; first, we have the use and development of weights; then the different weighing machines and apparatus; and finally the introduction of weights and measures to control commercial transactions.

From Seed to Electronics

At the height of Egyptian civilization the weights used were fashioned from bronze and often cast in the shape of animals, some in the shape of a cow, which was an ancient standard of value. This customer of making weights in the shape of animals and other decorative designs was practiced in Africa, India and the Far East using brass. Many other materials were used throughout the ages, including porcelain and pottery.

However, the first weights were not fashioned by man but by nature. In order to weigh small amounts precisely, small objects that were easily obtained and of a consistent size were needed. So the grains and seeds of plants were chosen for their elegant uniformity. A grain of wheat became the grain of weight. Mustard seeds were used to weigh gold in India. The seeds of the liquorices plant and of the carob tree were also used. The carob gave us carats, still used today to express the value of gold and diamonds, although it is now a metric carat.

The weights of seeds were eventually transformed into stone equivalents for the weighing of general goods, but other materials such as lead were used as well. Haematite or nephrite were reserved for weighing precious materials like gold.

From Pounds

The Romans gave us our pound weight which is derived from the Roman word Libra. This explains why our pound has such a strange abbreviation (lb) and why the astrological sign Libra has an equal-armed balance as its symbol.

In England there were, at one time, six different pound weights varying from 5,400 to 7,680 grains. Different pounds were used to weigh different commodities such as coins, gold or wool. Henry VIII began the task of standardizing the pound and Elizabeth I completed the work by dividing it into sixteen ounces which totaled 7,000 grains. The Roman pound (or Libra) was divided into twelve uncias, from which we derive our ounces and is referred to as the Troy system. The new Elizabethan pound with its sixteen ounces, known as avoirdupois, was used to weigh general goods, while the twelve ounce pound was reserved for weighing precious metals.

Advances in science are dependent upon accuracy. Every experiment requires superfine measurement so that it can be repeated anywhere in the world and its results independently verified. The problem for eighteenth century scientists was that no common system of measurement existed.

To Kilogrammes

In 1789 France had her revolution and the ensuing explosion of new thinking led to the development of revolutionary new system of measurement in which all the different physical properties were linked by interrelated units - the metric system. Imagine a hollow cube with sides measuring one tenth of a metre. Fill it with water and the volume of that water becomes one litre whilst its weight becomes one kilogramme. The master kilogramme, made from platinum, resides in Paris, whilst faithful copies, or witnesses, are held in major cities around the world, ensuring that a kilogramme weighs exactly the same from Kilmarnock to Karachi.

The First Weighing Apparatus

The first weighing machine was probably derived from the yoke, whereby it was discovered that two equal masses would balance if they were suspended from a beam that was supported at its centre. Balances were in use in Mesopotamia as early as 4000 years BC. They consisted of straight pieces of wood suspended by a cord passing through the centre. Holes, pierced in the ends of the beam, carried cords suspending the scale pans.

The accuracy of the beam scale, or balance, relies on ensuring that the distance from the fulcrum to each end of the beam is exactly equal. The holes were difficult to locate precisely and the cords moved about in the holes, so affecting accuracy.

2.1.1 THE ANALOGUE BATHROOM SCALE

The analogue spring scale has taken many forms. However, the same principles are involved. A lever with its fulcrum moved to the end of the lever. The weight is applied to the lever close to the fulcrum and a balancing supplied by the extension of a spring at the opposite end. See fig 2.2.

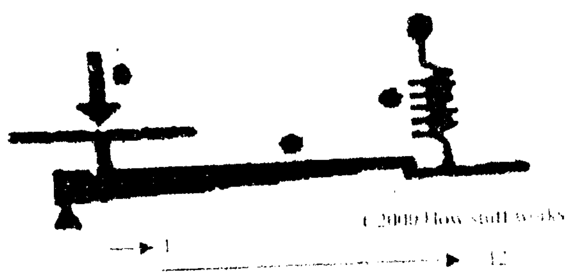


Fig 2.2: The Analogue scale balance principle.

This set up means the spring needs only to supply a fraction of the weight to the object to balance the lever. The ratio 1:2 means that the spring is extended until the restoring force reaches only ½ of the weight applied. This helps to keep scale compact.

The actual implementation in the scale involves the use of four levers with fulcrums at the corners to distribute the load on the base of the scale. The rear levers couple to the front levers at about half way their length. The front levers are then coupled to a steel plate connected to the bottom of a spring. The cover of the scale which is the platform on which the load rests transfers the weight to the levers. It is connected to the levers using four special brackets designed to fit into depression in the levers. They are fixed to the undesirable of the cover.

The vertical extension of the spring is converted to horizontal motion by a lever which rests on top of the steel plate. This lever follows the plate downwards when a eight is applied. An extended spring connected to this lever drives a metal bar having saw tooth grooves drives the wheel of a calibrated dial see figure 2.3:

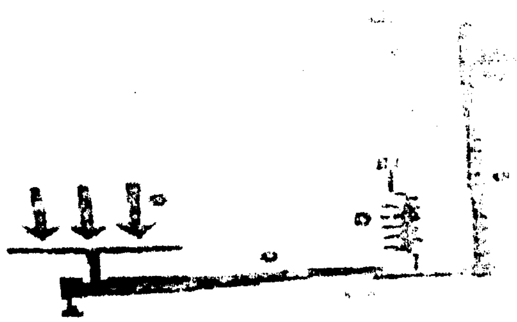


Fig 2.3: The Analogue scale system

2.1.2 Types of Weighing System Used Presently

Span adjustment: A span adjustment method for applying a known load to a weighing machine which produces an analog output, and effecting an adjustment so that a true weight value, in the form of a digital value conforming to the known load, is obtained, said method comprising the steps of:

(a) Producing a digital span adjustment value;

(b) Converting the digital span adjustment value into an analog span adjustment value;

(c) Converting the analog output of the weighing machine into a digital output value using an analog-to-digital converter, and comparing the digital output value and the digital value conforming to the known load, while changing a conversion characteristic of the analog-to-digital converter in accordance with the analog span adjustment value; and

(d) Sequentially changing the digital span adjustment value, in accordance with the relative sizes of the compared digital values, to obtain a true weight value, which conforms to the known load, as the digital output value produced as an output by the analog-to-digital converter [7].

A span adjustment apparatus for applying a known load to a weighing machine which produces an analog output, and effecting an adjustment so that a true weight value, in the form of a digital value conforming to the known load, is obtained, said apparatus comprising:

an analog-to-digital converter, operatively connected to the weighing machine and having a variable analog-to-digital conversion characteristic, for converting the analog output of the weighing machine into a digital output value; first means for storing a span adjustment value for adjusting the variable analog-to-digital conversion ' characteristic of said analog-to-digital converter; second means for storing the digital value conforming to the known load; comparison means, operatively connected to said second means and said analog-to-digital converter, for comparing the digital value conforming to the known load and the digital output value from said analog-to-digital converter; and means, operatively connected to said first means and said comparison means, for sequentially changing the span adjustment value in accordance with the relative sizes of the digital values compared by said comparison means to obtain a true weight value, which conforms to the known load, as the digital output value from said analog-to-digital converter[8].

Combinational Weighing System

A combination weighing machine, which is typically used for packing a plurality of articles in each bag or the like, including a plurality of weighing balances for weighing a plurality of articles each at the same time, and arithmetic means for selecting some of these weighing balances so that the total weight of the articles thereon falls within a predetermined allowable range, the machine also includes zero-point correction means arranged such that, by applying a zero-point correction command signal from the outside, the loading operation of a selected balance is inhibited and, after the unloading operation, this balance is left vacant, and that, under such condition, the weight signal output from this balance is cancelled or nullified prior to arrival at the arithmetic means[9].

CHAPTER THREE

3.1 DESIGN ANALYSIS

Below are the various modules that describe the principle of operation of a digital weighing machine.

3.2 POWER SUPPLY CIRCUIT

The block diagram shown below is a typical D.C power supply system and it incorporates the transformer, rectifier, filter and regulator.

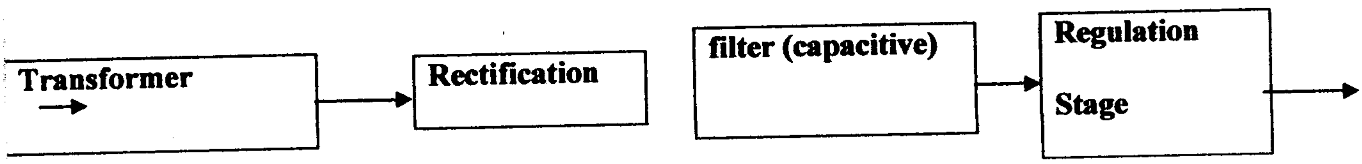


Fig: 2.1 Block diagram of power supply unit

3.2.1 TRANSFORMAION

A transformer is a static or stationary electrical device by means of which electrical power in one circuit is transformed into electrical power of the same frequency in another circuit through the principle of electromagnetic induction. It can raise or lower the voltage in a circuit but with a corresponding decrease or increase in current [10].

A transformer consist of two or more coils of wire placed near each other so that most of the magnetic field generated by one coil passes through the other coil.

In practice a transformer always has a finite winding which cause the efficiency to be less than 100% for a sinusoidal input voltage, the flux, Φ varies alternately i.e. $\Phi =$

$\Phi max \times$ sinwt and the instantaneous voltage in primary is to FARADAY'S LAW and it is stated mathematically as:

$$E = -d\Phi/dt = wN\Phi_{max} \times Cos(wt)$$

$$= 2\pi fN\Phi_{max} \times Cos(wt)$$

Where $W = 2\pi f$ and $\pi = 3.14$

The R.M.S value of E is given as:

$$E\ rms = \frac{2 \times 3.14 \times F \times N \times \Phi max}{\sqrt{2}} = 4.44FN\Phi max$$

Since the flux is the same for the primary and secondary coils. The ratio of the secondary voltage and current can be derived from

$$V2/V1 = E2/E1 = \frac{4.44 \times F \times N2 \times \Phi_{max}}{1.44 \times F \times N1 \times \Phi_{max}}$$

$$V2/V1 = N2/N1 \qquad (1)$$

Where

V1 = Primary input voltage

V2 = Secondary output voltage

N1 = Number of primary turns

N2 = Number of secondary turns

When a transformer circuit is closed magneto to motive force (mmf) of I_1N_1 ampere- turn develops and the ratio of primary current and secondary current is attained

$N_1I_1 = N_2I_2$

$N_1/N_2 = I_2/I_1$

Combining 2.1 and 2.2 gives

$V_2/V_1 = N_2/N_1 = I_1/I_2$

Where,

I_1 = Primary current

I_2 = Secondary current

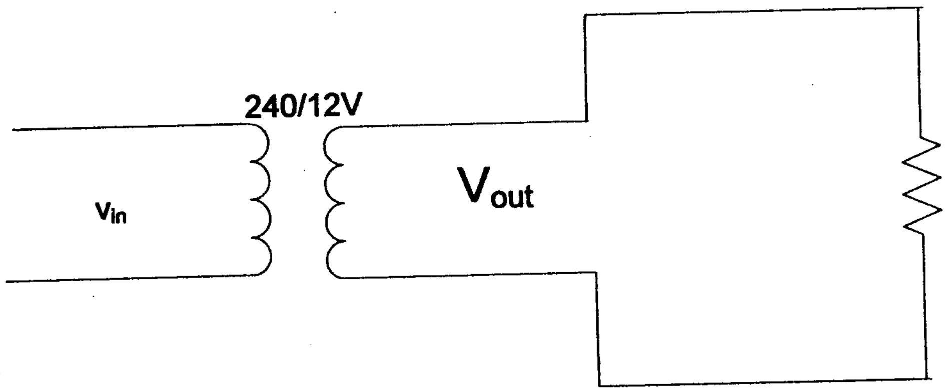


Fig: 2.2 Transformation Circuit

3.2.2 RECTIFICATION

Rectification is the conversion from A.C (alternating current) to D.C (direct current) voltage through the use of a rectifier. A rectifier circuit which employs one or more diodes to convert A.C into pulsating D.C voltage.

A rectifier may be used to carry out half or fill rectification depending on the application. This project is concerned with full wave bridge rectifier. The common type of bridge rectifier makes use of four discrete diodes arranged in a bridge network. They are connected as shown in figure 2.3(a).

Diodes D1 and D2 conduct an alteration as illustrated in figure 3.2(a) while D3 and D4 conduct negative half cycle on alternation. Both conducting paths deliver current to the load in the same direction [10].

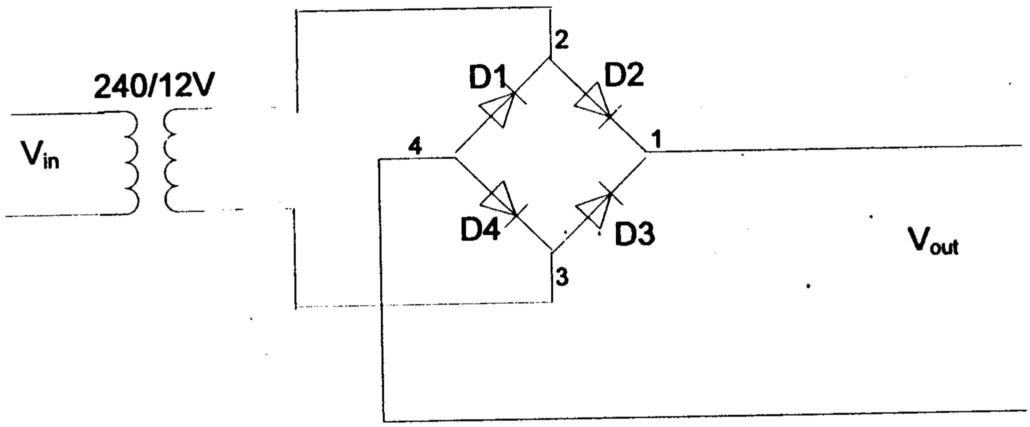


Fig 2.3 (a) Bridge rectifier

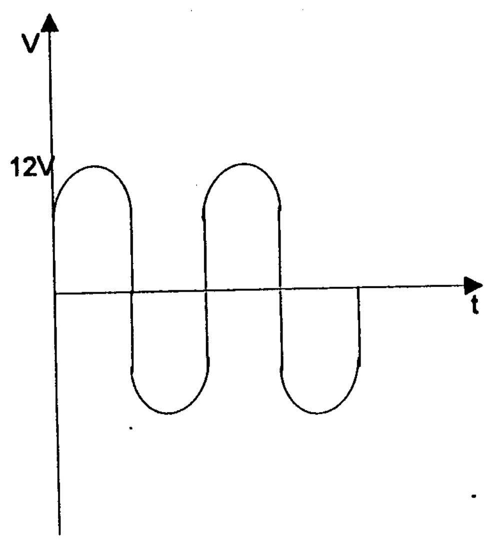


fig: 2.3(b) Input to a bridge rectifier

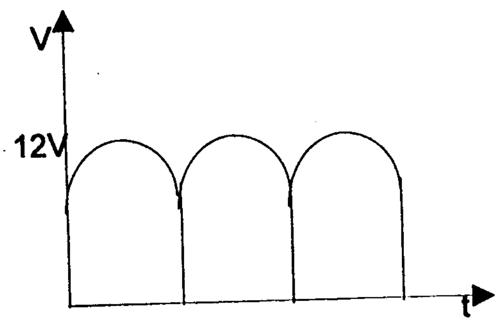


Fig:2.3 (c) output from bridge rectifier

3.2.3 FILTERING

A filter is required to smooth the pulsating D.C output voltage from the rectifier. Various types of filter are built using a combination of inductors and capacitor or each single one in combination with a resistor. However a single capacitor in parallel with the output from the rectifier performs the required filtering action.

Capacitor are used as shorts to the A.C source particularly one of very high frequency hence capacitor would remove any A.C component still contained in the output voltage from the rectifier. The capacitor stores energy during the conduction process and deliver it to the load during the non-conducting period, hence the time of flow through the load is prolonged.

The filter capacitor must be large enough to store sufficient amount of energy to provide a steady supply of current to the load, otherwise the output will drop as the load demands more up to date [11].

3.2.4 REGULATION

Unregulated power supply suffers from the drawbacks that their D.C output volt changes with changes in load or input voltage. A regulated power supply can be obtained by using a voltage regulator circuit.

A regulator is an electronic control circuit which is capable of providing a nearly constant D.C output voltage even when there are variations in load or input voltage.

The change in voltage from no-load to full-load condition is called voltage regulation. The aim of this voltage regulator circuit is to reduce these variations to zero or at least to the minimum possible value.

$$\% \text{ regulation} = \frac{V_{max} - V_{min}}{V_{max}} \times 100 \qquad (2)$$

Where V_{max} = maximum D.C output; V_{min} = minimum D.C output voltage [11].

3.3 LOAD CELL TRANSDUCER

A load cell is an electronic device (transducer) that is used to convert a force into an electrical signal. The conversion is indirect and happens in two stages through mechanical arrangement; the force being sensed deforms a strain gauge. The strain gauge converts the deformation (strain) to electrical signals. A load cell usually consists of four strain gauges in a Wheatstone bridge configuration [12]. The electrical signal output is typically in order of a few millivolts and requires amplification by an instrumentation amplifier before it can be used. The output of the transducer is plugged into an algorithm to calculate the force applied to the transducer.

We have both 4 – wire 6 –wire load cell. But for my design an using a 4 – wire load cell. The load cells should be electrically connected in such a way that signal (output) lines, excitation (power supply) and sense (when present) lines are in parallel usually the connection is not made at the indicator, but in a separate housing, a so called junction box, located adjacent to the weighing system.

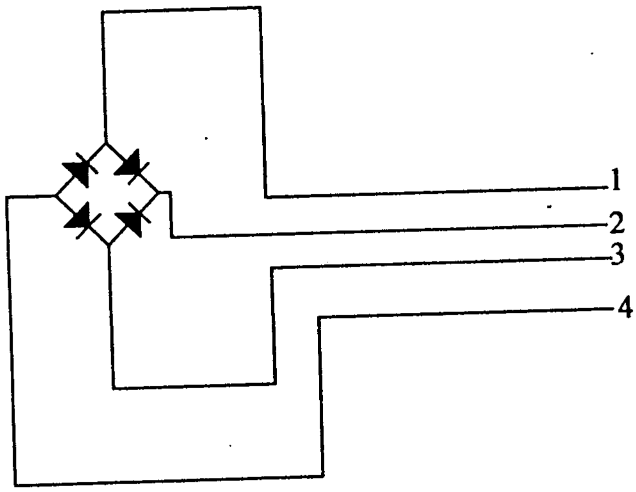


Fig 3.6: A load cell transducer [12]

1: + Excitation 2: - Excitation
3: + Output 4: - Output

3.3.1 SIGNAL TRIM

The principle of signal trim is based on placing a relatively high parallel resistance (47 → 220Ω) between the two outputs leads of each load cell, to shunt a small part of its signal. Because of the low voltages and current values in the signal circuit, it takes a large resistance to accomplish a small output change. The main benefit of signal trim is to avoid corner load differences causes by:

i. Unequal load distribution.

ii. The parallel connection. Each load cell will be loaded with the resistance of the other load cells.

3.3.2 ELECTRONIC WEIGHING

Electronic Weighing centers around strain gauge transducers or load cells, sensing instruments which convert applied force to a resistance change. The more the weight, the larger the variation of the resistance and the higher the output voltage. This is in accordance with Ohms law:

$$V \propto R \text{ [13]}$$

$$V = IR \qquad (3)$$

The transducer is configured as a Wheatstone bridge made up of four resistive elements. Two are strain mechanically arranged to react positively to applied force, while the remaining two are arranged to react negatively to the same force. An excitation voltage applied to one pair of bridge terminals transforms to a measurement signal voltage on the other with no force or weight applied the bridge is in balance and the signal voltage zero. As force is applied, two strain gauges are put in tension, the other two in compression, their effective resistance change in opposite direction. The Wheatstone bridge produces a signal voltage proportional to applied force.

Load cell specification includes capacity (the full load) and output voltage ratio. The output is typically as 2Mv/V i.e. 2 millivolts of signal voltage per volt of excitation at capacity. If the excitation were 10 volts, the load cell signal would be 20 millivolts. By the nature of the Wheatstone bridge, load cells may be used individually or combine for additive weighing for example, a platform may be supported of four load cells electrically connected so that their signals sum to equivalent load cell. The signal measurement then represents the total weight on the platform, independent of the distribution of the weight on four corners [13].

The signal is differential and its magnitude is typically measured in millivolts. A typical analogue input channel in data acquisition system delivers 12 bits of signal precision, measured with the assumption that the input signal span a range of 0 to 5 volts that is, the digital conversion is a 12bit representation of a 5volts input. If the input were only 5 millivolts (0.001 of input range for analogue – to – digital conversion, but not typically of a load cell signal), the 12 bit conversion results would be 10 bits equal to zero followed by 2 bits of significant data.

Clearly an input amplifier stage is required. An input amplifier stage consisting of an instrumentation amplifier converts the small differential input into a range which is acceptable to an analog to digital converter. The amplifier also provides differential input and gain set by single external resistors. Its offset controls put the amplifier out put in the right range [13].

3.3.3 CONVERSION TO WEIGHT (UNITS).

The load cell output is a voltage. The weight or force is in some other unit, pounds, kilograms, etc. here the microcontroller plays a key and vital role. The micro controller is been programmed to read the output coming from the ADC and convert it to any units of your choice. Based on how it was programmed.

3.4 INSTRUMENTATION AMPLIFIER

An instrumentation (0r instrumental) amplifier is a type of differential amplifier that has been outfitted with input buffer, which eliminate the need for input impedance matching and thus make the amplifier particularly suitable for use in measurement and test equipment. Additional characteristics include very low DC offset, low drift, low noise, very high open- loop gain, very high input impedances.

Instrumentation amplifiers are used where great accuracy and stability of the circuit both short and long terms are required.

Although the instrumentation amplifier is usually shown schematically identical to a standard opamps, the electronic instrumentation amplifier is almost internally composed of 3 op – amps. These are arranged so that there is one opp – amp to buffer each input (+, -) and one to produce the desired output with adequate impedance matching for the function [14]. The most commonly used instrumentation amplifier circuit is shown in the figure below.

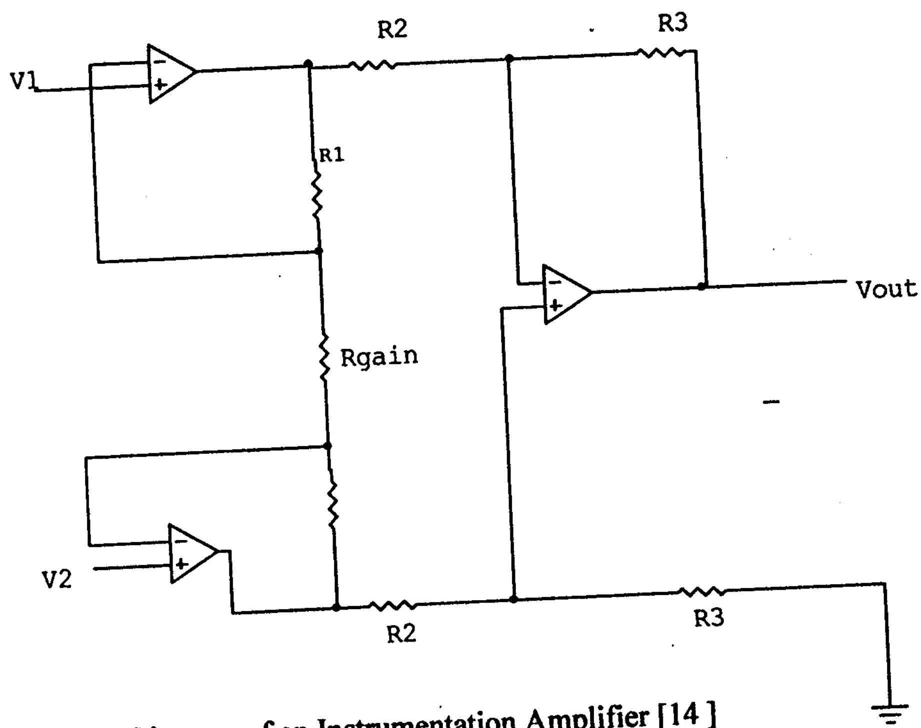


Fig 3.7: Diagram of an Instrumentation Amplifier [14]

The gain of the circuit is

$$\frac{V_{out}}{V_2 - V_1} = \left(1 + \frac{2R_1}{R_{gain}}\right)\frac{R_3}{R_2} \tag{4}$$

The ideal common – mode gain of an instrumentation amplifier is zero. In the circuit shown, common – mode gain is caused by mismatches in the value of the equally – numbered resistors and by the non – zero common mode gains of the two input op-amps. Instrumentation amplifiers can be built with individual op-amps and precision resistors, but are also available in integrated circuit. An IC instrumentation amplifier contains closely matched laser – trimmed resistors, and therefore offers excellent common –mode rejection.

3.5 THE ANALOGUE TO DIGITAL CONVERSION

The analogue to digital conversion system comprises of two integrated circuits (IC). The ADC 0804 is the analogue to digital converter while the 40103A is responsible for the base 2 to base 10 conversion.

ADC 0804

The ADC 0804 family is a series of three CMOS 8 bit successive approximation A/D converters using a resistive ladder and capacitive array together with an auto-zero comparator. These converters are designed to operate with microprocessor controlled buses using a minimum of external circuitry [15]. The 3 state output data lines can be connected directly to the data. The feature of an ADC 0804 includes:

i. Compatible with most microprocessors

ii. Differential Inputs

iii. 3 – state outputs

iv. Logic levels TTL and MOS compatible

v. Single 5V supply

vi. Analogue Input range 0V to V_{CC}

vii. Guaranteed specification with 1MHz clock

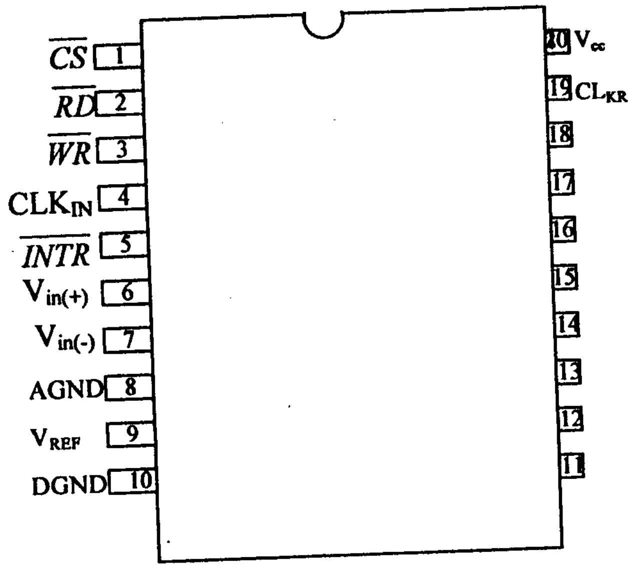


Fig 3.8: Pin Configuration for ADC 0804 [15]

Table 3.1: ADC 0804 Pin Description [15]

S/N	Symbol	Function	Description
1	CS	Input	Chip select line from microprocessor control
2	RD	Input	Read line from microprocessor control
3	WR	Input	Write line from microprocessor control
4	CLK IN	Input	Clock interrupt line
5	INTR	Output	Output
6	V_{in+}	Input	Analogue voltage (+ve input)
7	V_{in}	Input	Analogue voltage (-ve input)
8	AGND	Power	Analogue ground
9	V_{ref}	Input	Alternate voltage reference

10	DGND	Power	Digital ground
11	DB_0	Output	MSB Data output
12	DB_1	Output	Data – output
13	DB_2	Output	Data – output
14	DB_3	Output	Data – output
15	DB_4	Output	Data – output
16	DB_5	Output	Data – output
17	DB_6	Output	Data – output
18	DB_7	Output	LSB Data Output
19	CLK R	Input	External resistor connection for clock
20	V_{cc}	Power	5V power supply and primary voltage reference

3.5.1 FUNCTIONS DESCRIPTION

These devices operate on the successive approximation principle. Analogue switches are closed sequentially by successive approximation logic until the input to the autozero comparator [$V_{in\,(+)} - V_{in\,(-)}$] matches the voltage from the decoder. After all bits are tested and determined, the 8 bit binary code corresponding to the input voltage is transferred to an output latch.

Conversion begins with the arrival of a pulse at the WR input if the CS input is low. On the high – to – low transition of the signal at the WR or the CS input, the SAR is initialized, the short register is reset, and the INTR output is set high. The A/D will remain in the reset state as long as the CS and WR inputs remain low conversion will start from one to eight clock periods after one or both of these inputs makes a low - - to – high transition [15].

After the conversion is complete, the INTR pin will make a high – to – low transition. This can be used to interrupt a processor, or otherwise signal the availability of a new conversion result. A read (RD) operation (with CS low) will clear the INTR line and enable the output latches. The device may be run in the free-running mode. A conversion in progress can be interrupted by issuing another start command.

3.5.2 ANALOGUE DIFFERENTIAL VOLTAGE INPUTS AND COMMON – MODE REJECTION

These A/D converters have additional flexibility due to analogue differential voltage input. The $V_{in(-)}$ input (pin 7) can be used to subtract a fixed voltage from the input reading (tare correction). The time interval between sampling $V_{in(+)}$ and $V_{in}(-)$ is 4.5 clock diodes. The maximum error due to this time difference is given by:

$V(max) = (V_p)(2F_{cm})(4.5/F_{c/k})$ [15]

Where

V= Error voltage due to sampling delay

V_p= Peak value of common – mode voltage

F_{cm} = Common mode frequency

For example, with a 60MHz common mode frequency, F_{cm} and a1MHz A/D clock, F_{ck} keeping this error to ¼ LSB (About5mV) would allow a common – mode voltage V_p which is given by:

$$V_p = \frac{V(\max)(F_{ck})}{(2F_{cm})(4.5)}$$

$$V_p = \frac{(5\times10^{-3})(10^{4})}{(6.28)(60)(4.5)}$$

$$V_p = 2.95V$$

3.5.3 BLOCK DIAGRAM OF AN ADC 0804

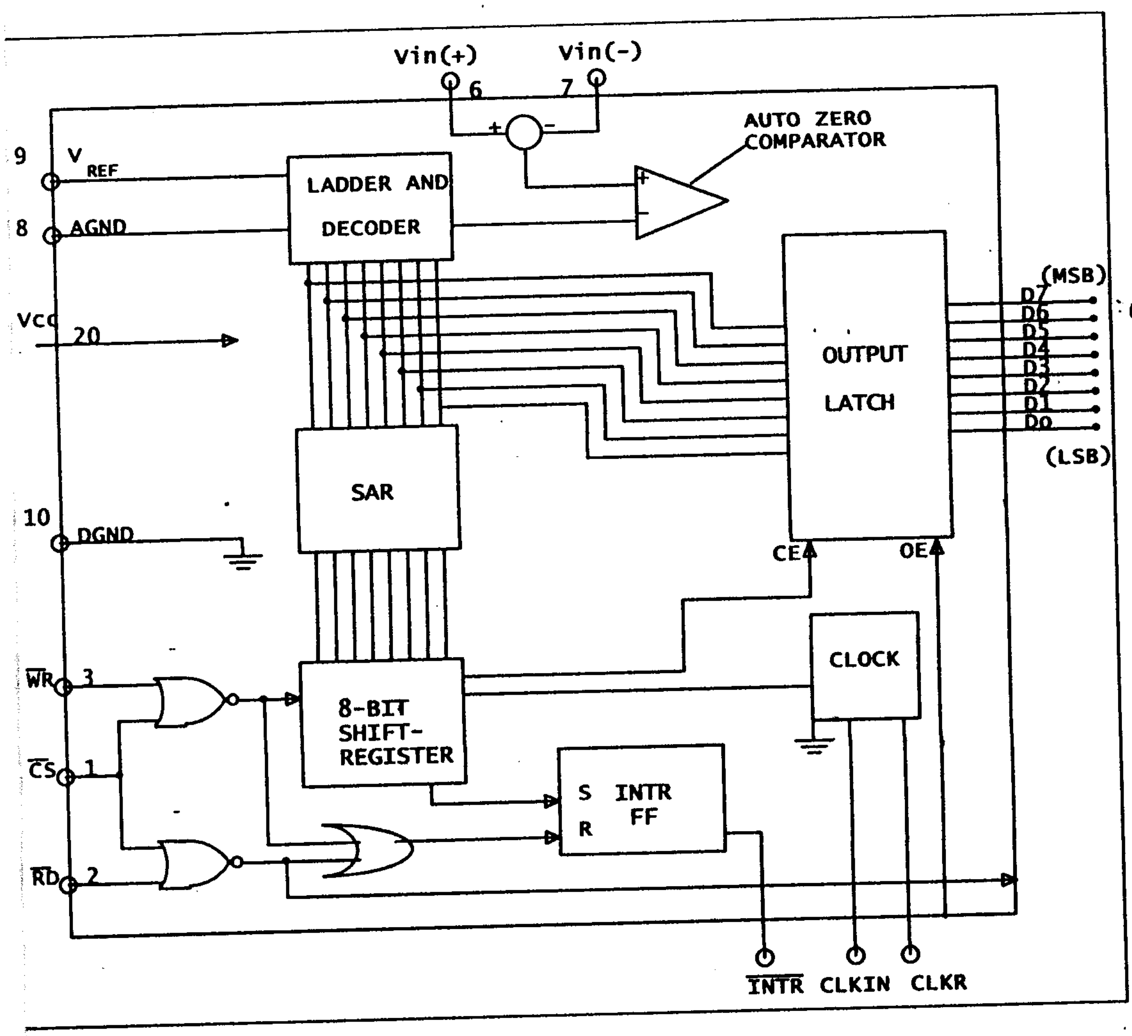


Fig 3.9 Block Diagram of an ADC 0804 [16]

3.6 MICROCONTROLLER (PIC 16F84A)

The PIC 16F84A belongs to the mid range family of the PIC microcontroller devices. The program memory contains words, which translate to 1024 instructions. Since each 14 – bit programme memory word is the same width as each device instruction. The data memory (RAM) contains 68bytes. Data EEPROM is 64 bytes [17].

There are also 13I/O pins that are user configured on a pin – to – pin basis. Some pins are multiplexed with other device functions. These functions include:

i. External interrupt
ii. Change on PORT B interrupt
iii. Timer 0 clock input

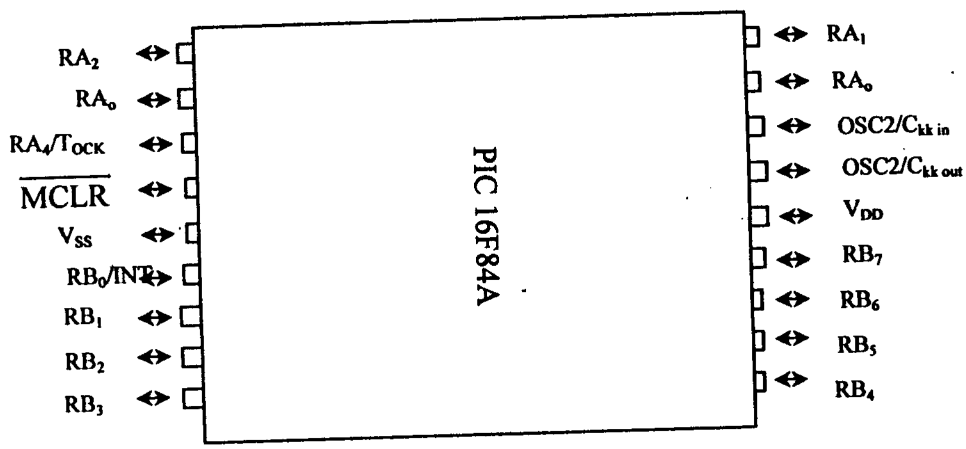


FIG 3.10: Pin Configuration for PIC 16F84A [18]

Table 3.2: PIC 16F84A Pin out Description [19]

S/N	Symbol	Function	Description
1	RA_2	INPUT/OUTPUT	Port A is bi-directional I/O port
2	RA_3	INPUT/OUTPUT	PORT A is bi-directional I/O port
3	RA_4/T_{ckI}	INPUT/OUTPUT	Clock input 2 timer/counter
4	MCLR	INPUT	Master clear (reset)
5	V_{SS}	POWER	Ground Reference for logic I/O pins
6	RBO/INT	INPUT/OUTPUT	External interrupt pin
7	RB1	INPUT/OUTPUT	
8	RB2	INPUT/OUTPUT	
9	RB3	INPUT/OUTPUT	
10	RA1	INPUT/OUTPUT	
11	RA0	INPUT/OUTPUT	
12	OSC1/CLK IN	INPUT	Oscillator crystal input clock
13	OSC2/CLK OUT	OUTPUT	Oscillator crystal output clock
14	V_{DD}	POWER	Positive supply for logic & I/O pins
15	RB7	INPUT/OUTPUT	Interrupt – on – change pin program data
16	RB6	INPUT/OUTPUT	Interrupt – on – change pin program data
17	RB5	INPUT/OUTPUT	Interrupt – on – change pin
18	RB4	INPUT/OUTPUT	Interrupt – on – change pin

3.7 LIQUID CRYSTAL DISPLAY (LCD)

A display means an opto-electronic device that can show a number ("numeric" display), a hexadecimal digit, namely 0 – 9 and A –F ("hexadecimal display"), or any letter or number ("alphanumeric display"). The dominant display technologies today are LEDs and LCDs. LCD are the newer technology, with significant advantages for:

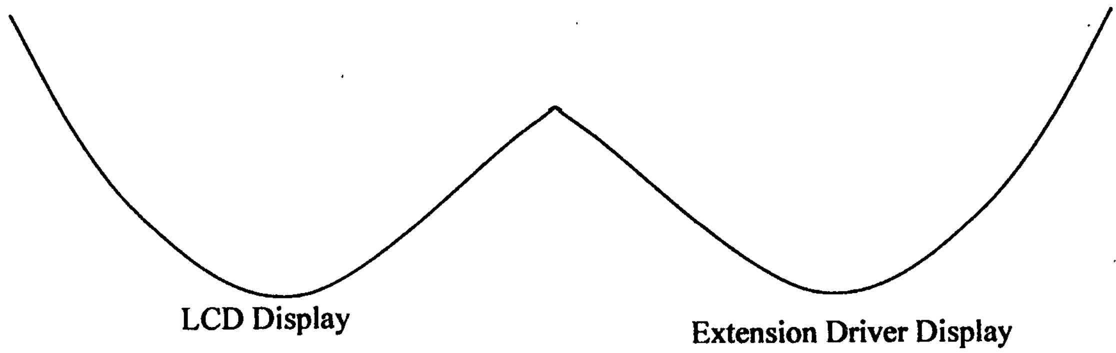
i. Battery operated equipment, owing to its very low power dissipation.

ii. Equipment for use in high custom shapes and symbol

iii. Displays with many digits or character.

In my project work I decided to use LCD because of the above advantages mentioned above the LCD I use is a 2 x 16 LCD

Display Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	[20]
DDRAM Address	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	

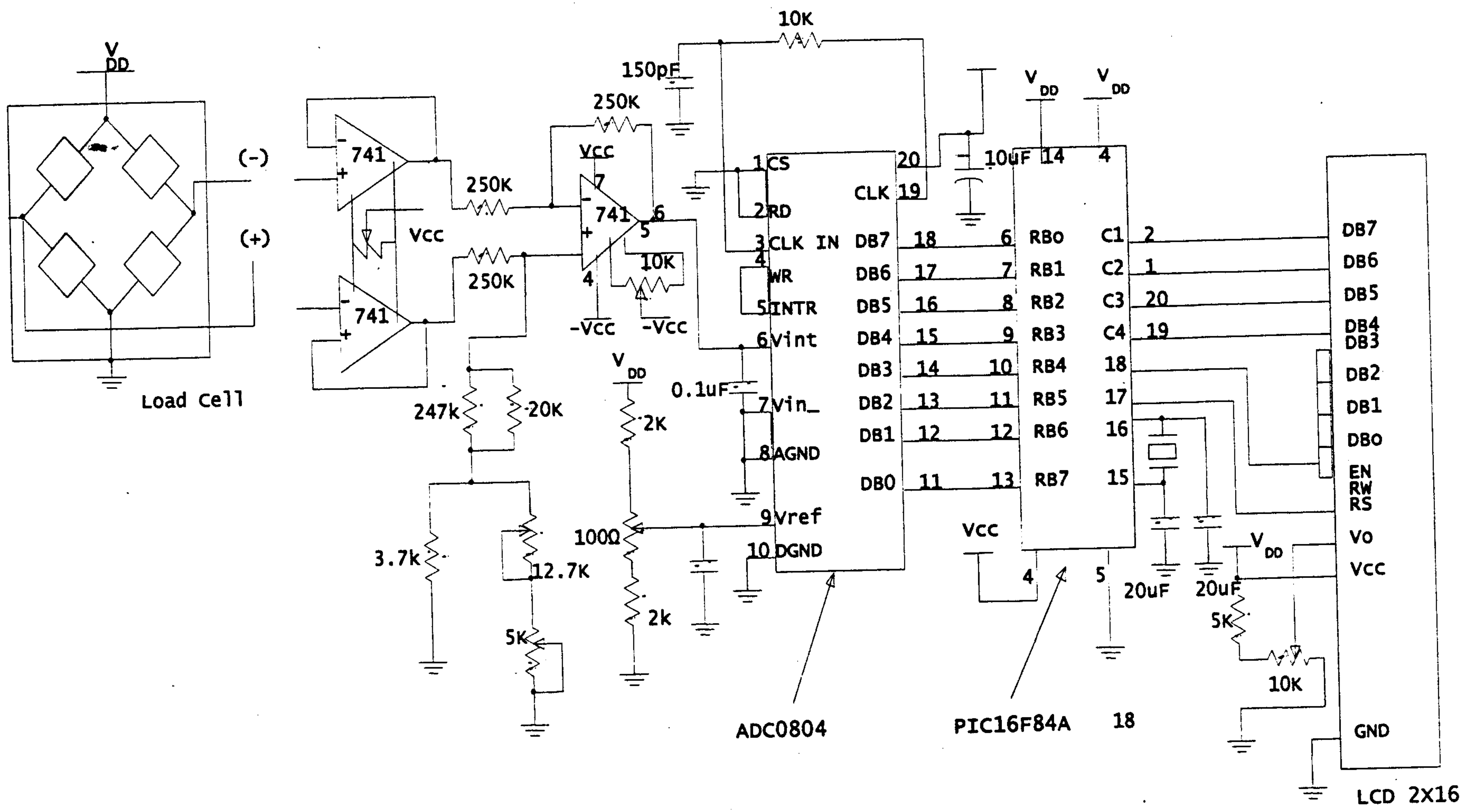


r
ift left

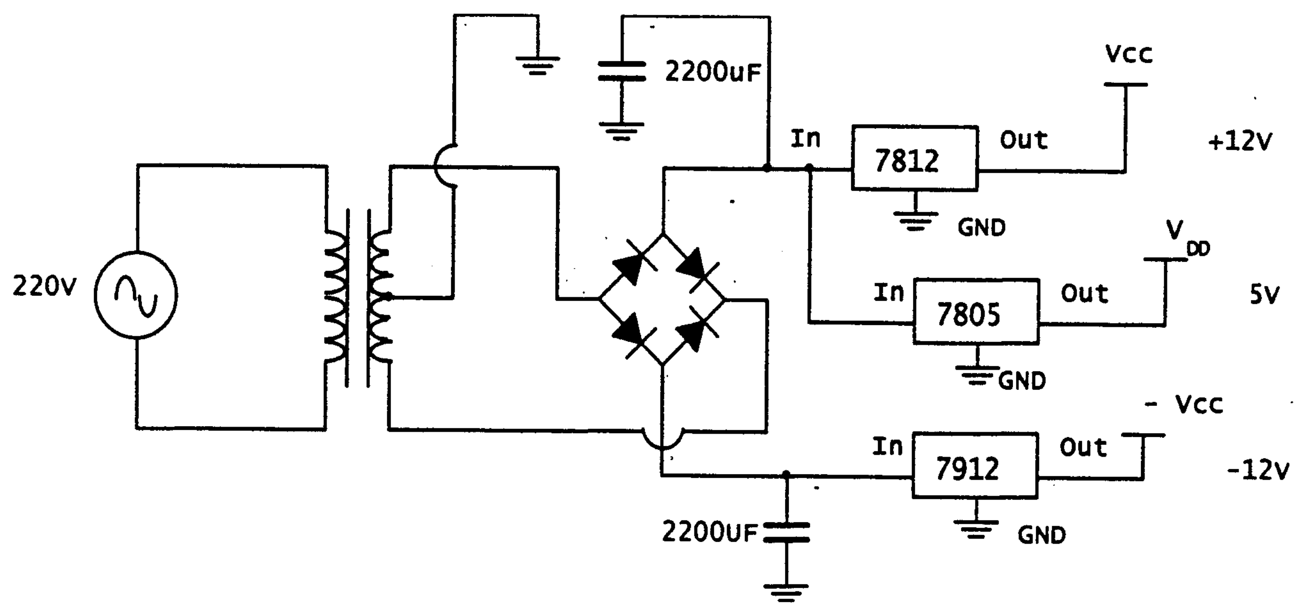
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	[20]
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
27	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	[20]
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	

Fig: 3.11: Shows 2 line by 16 – character displays



CIRCUIT DIAGRAM OF A DIGITAL ELECTRONIC LOAD MEASURING DEVICE.



POWER SUPPLY FOR A DIGITAL ELECTRONIC LOAD MEASURING DEVICE

CHAPTER FOUR

4.1 CONSTRUCTION

In this chapter, we are mostly concerned with the construction and testing of the device. After designing the various modules illustrated in the previous chapter, they were assembled on a project board (bread board). After the assembling, the various modules were tested using a DC 12V from the lead-acid accumulator.

4.2 TESTING

In testing the designed and constructed project work, the following steps were taken; these steps are sequentially listed below;

Step 1: To ensure that all the components to be used are functionally operating, they were first tested with a digital multimeter and failed ones replaced before finally soldering them on the veroboard.

Step 2: To ensure that there was no breakage in the circuit path on the veroboard, immediately after soldering on veroboard, the circuit path was tested using the Digital Multi-meter. This was done to also ensure continuity of circuit on the veroboard.

4.3 DISCUSSION OF RESULT

The sole reason of testing all the components before they were finally soldered on the veroboard is to avoid the painstaking effort it will take to disolder faulty components at the end of the day. From the continuity test carried out on the veroboard to check the circuit path, it was discovered that the circuit was in a perfect working condition as continuity was ensured.

Simulation of the circuit design was also done as mentioned earlier, with the sole objective of comparing the results obtained from design calculations to that obtained from simulation. The two results when compared closely correspond with only a very slight discrepancy in values.

4.4 PROBLEMS ENCOUNTERED

A few difficulties accompanied the implementation of this project. They include

1. Availability of needed components within Minna.Some could be found in other cities and a few had to be replaced with the most suitable alternatives. This added to my project cost and design to.

2. Needed information was difficult to find.

3. Skill had to be acquired on the job. This was advantageous on one hand but it hampered the speed of the work.

4.5 TROUBLESHOOTIHG

1. If A.C power does not come on, first check the power plug and the rectifier circuit. If there is any one faulty, then replace the component.
2. If after powering and there's no excitation check the connection between the load cell.
3. Once excitation is notice, then you can go ahead and measure thy desire quantity
4. When the desired quantity to be measured fails to display the connections to the LCD should be properly checked and corrected. The LCD can be removed and fix again to ensure it's properly fix.

4.6 MATERIALS USED IN THE DESIGN AND CONSTRUCTION

The materials used to achieve the weighing system are;

(1) Bread board (project board)

(2) Soldering iron

(3) Conducting wire

(4) Vero board

(5) The case

(6) Load cell transducer.

(7) PIC16F84A

(8) ADC

CHAPTER FIVE

5.1 RECOMMENDATIONS

I recommend that a 24-bit Analog-to-Digital Converter be used. This is to ensure that what an individual weighs is able to display up to two or more decimal places. Therefore, enabling an object or device below 1KG the ability to be measured correctly.

5.2 CONCLUSION

The digital weighing machine was constructed and the results were obtained with minimally deviated from expectations. It was achieved costly and it maintained the portability known with the analogue bathroom scale. The digital weighing machine functions well for the measurement of human weight and it could fast replace the analogue scale in homes and hospitals. It shows the relevance of electronics to every face of human life

APPENDIX

PROGRAM IMPLEMENTATION

```
Define ADC_CLOCK = 3  'default value is 3
Define ADC_SAMPLEUS = 10  'default value is 20
Define LCD_BITS = 8  'allowed values are 4 and 8 - the number of data interface lines
Define LCD_DREG = PORTB
Define LCD_RSREG = portc
Define LCD_RSBIT = 1
Define LCD_EREG = portc
Define LCD_EBIT = 3
Define LCD_RWREG = portc  'set to 0 if not used, 0 is default
Define LCD_RWBIT = 2  'set to 0 if not used, 0 is default
Define LCD_COMMANDUS = 5000  'delay after LCDCMDOUT, default value is 5000
Define LCD_DATAUS = 100  'delay after LCDOUT, default value is 100
Define LCD_INITMS = 100  'delay used by LCDINIT, default value is 100
'the last three Define directives set the values suitable for simulation; they should be omitted
for a real device
Define CLOCK_FREQUENCY = 4

Dim an0 As Word

TRISA = 0xff  'set all PORTA pins as inputs
trisc = 0x00
portc.5 = 1
adcon1 = 0  'set all PORTA pins as analog inputs

Lcdinit 1  'initialize LCD module; cursor is blinking
Lcdcmdout LcdClear  'clear LCD display
        Lcdout "Device designed"  'text for the line 1
        Lcdcmdout LcdLine2Home  'set cursor at the beginning of line 2
        Lcdout "by Moses"  'formatted text for line 2
        WaitMs 10000  'larger value should be used in re
loop:
        Adcin 0, an0

        an0 = an0 / 10
        Lcdcmdout LcdClear  'clear LCD display
        Lcdout "Applied weight="  'text for the line 1
        Lcdcmdout LcdLine2Home  'set cursor at the beginning of line 2
        Lcdout "Value: ", #an0, "Kg"  'formatted text for line 2
        WaitMs 1000  'larger value should be used in real device
Goto loop  'loop forever
End
```

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