DESIGN AND CONSTRUCTION OF DIGITAL WEIGHING MACHINE

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DEDICATION

This work is dedicated to the Almighty God, my Keeper, Helper, and Sustainer. I also dedicate this project to my caring Parents Mr. & Mrs. M. A. Jigah, my siblings Patience, Titus, Simeon, Josephine, Joseph, Pauline and my dear one Yetu.

DECLARATION

I JIGAH EZRA MAWO declare that this work was done by me and has never been presented else where for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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8/12/07

Date

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Date

Name of external Examiner

Date

ACKNOWLEDGEMENT

My profound gratitude goes to the Almighty God, my Keeper, Helper and Sustainer for bringing me to the completion of my first degree program.

I am so grateful to my project supervisor Engr. Dr. Y.A Adediran for his guidance, sacrifice and tolerance which brought this project to completion.

I also use this opportunity to thank my parents Mr. and Mrs M. N. Jigah for their patience, love and financial support given to me throughout my degree program. My special thanks go the entire Jigah's family especially Mr. and Mrs. R.G Jigah. Also to my friends Samuel, Emopy, Ernest and Caroline.

I am finally gratefully to my dear friend Yetu for her love, prayers and encouragement.

TABLE OF CONTENTS

ABSTRACT

The project is about design and construction of digital weighing machine, the device is aimed at measuring human weight and display the weight in Kilogram on Light Emitting Diode (LED) 7 – Segment display. The target is for the device to measure up to 120Kg of human weight exerted on it. The basic concept of the design is the application of Analogue – to – Digital Converted (ADC). The weight exerted on the device causes a displacement which is made into voltage through a variable resistor set – up. The analogue signal is converted to digital through the ADC. The corresponding codes are calibrated and displayed on a seven segment display panel in Kilogram as weight. The result showed that the difference in measurement from the project and other mechanical weighing machine is quite small.

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

The project is about a digital weighing machine with maximum weighing capacity of 120Kg. Digitally operated machines are attributed to more interesting features, especially in terms of accuracy in reading. They can also be easily interfaced to a computer for data processing.

The design involves the use of modern electronic components, especially complementary metallic Oxide Semi – conductor(CMOS) integrated circuit such devices are known for flexibility, low power consumption, wide operating power supply range, low cost and availability.

These features, coupled with lot more, make the project of good economic importance.

1.1 HISTORY AND DEVELOPMENT OF WEIGHING MACHINES

Weight 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 the system of weight and measures.

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 cow, which was an ancient standard of value.

However, the first weight were not fashioned by man but by nature. In order to weigh small amounts precisely, small objects that were easily obtained and a consistent size were needed. Therefore, grains and seeds of plants were chosen for their elegant uniformity. Mustard seeds were used to weigh gold in India. The seeds of liquorices plants and of the Carob tree were also used. The carobs gave us Carats, still used today to express the value of gold and diamonds, although it is now a metric Carat.

The first weighing machine was probably derived from the yoke [1]. It was discovered that two equal masses would balance if they were suspended from a beam that was supported at its centre.

Balances were used in Mesopotamia as early as 4000 years BC. They consisted of straight pieces of wood suspended by a cord passing through the centre [1]

The accuracy of the bean 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]

The earliest bean balances had a capacity of 6.5g and sensitivity of 0.13g and beam balances with a 130g capacity had a sensitivity of 1.95g [3]. The eight standards of weight used by the ancient civilization of the middle east each evolved from the shekel. Shekel standard ranged from 7.78g (Palestine) to 14.13g (Phoenician). The larger units only evolved over time as there were no early commercial applications for weighing. These larger weights were known as minas and comprised 25, 50 or 60 shekels. [3]

One of the first price-indicating scales to be manufactured commercially appeared in America in 1887. Based on a steely and supporting a weighing plat form, its computer consisted of a flat rectangular chart attached to the steelyard. A weighed cursor, graduated vertically into prices per pound, was slid along the steelyard and the price of the goods could be read off the chart at the point where a balance was achieved.

In the late part of the 19th century the development of accurate self – indicating scales for industry revolutionalized the weighing process. Loose weight and sliding poises were eliminated in those machines, which gave an almost instant indication of the weight of goods. Pendulums were applied to the Roberval and Beranger designs.

The weight from the scale beam, via a cam or pulley, allowed a pointer to traverse the chart and indicate the weight.

Yet another innovation, the Avery Dial recorder fitted to industrial weighing machines, printed a fraud - proof record of all goods weighted on the scale. The printed tickets also had the advantage of being much easier to read than hand written notes.

From the late 1940s mechanical weighing machines began to combine with electronics. But it was not until the devices called load cell an digital electronics were invented that complex and bulky lever systems and knife edges were replaced for more accuracy and acceptability [2].

1.2 AIMS AND OBJECTIVES

The project is aimed at the design and construction of digital weighing machine. It is designed to digitally measure and display human weight up to 120kg.

1.3 SCOPE OF WORK

The project deals with resistive weight sensor for measurement. The reading is done in Kilogram scale, in which the maximum capacity is 120Kg. The device is powered from an AC source. Complementary Metallic Oxide Semiconductor (CMOS) are mainly put into use in the design of the device.

1.4 METHODOLOGY

The design involves the manipulation of corresponding displacement of a particular hauman weight on a spring system. It is quite evident that such displacement is directly proportional to the weight for a given spring system.

Moreover, the displacement is made into voltage through a variable resistor set – up. The Analogue signal is converted to digital through Analogue – to – Digital Converter (ADC). The corresponding codes are calibrated and displayed on a seven – segment display panel as weight. The process part is quite simple so as reduce the difficulty in achieving the aim.

1.5 MERIT AND LIMITATION

The project involves easy – to – use electronics Components. Therefore, less technical knowledge is required in implementing the work.

But, the same components reduce the performance of the device altogether. The measuring sensitivity ignores weight below 1kg. Infact, the design and construction is not purely digital due to related mechanical attachment.

CHAPTER TWO

LITERATURE REVIEW

2.1. THEORETICAL BACKGROUND

Load cells, or transducers, now lie at the heart of every electronics machine. Precision load cells convert weight into electronic signals, and are manufactured for a wide range of products, from a sensitive and delicate scientific balance to weighbridge for a train. Each load cell contains thin, metal foil electrical resistors, known as strain gauges. When a load is applied, the strain gauge is compressed changing its electrical resistance and thereby changing its output signal in proportion to the weight exerted on it. [1]

Moreover, from the cells electronics, weight information together with other data, such as calibration are fed via an analogue – to – Digital Converter. This processes all the calculations, descri0tions and other information which is then digitally displayed. [3]

Accuracy in the electronic age means time and distance can now be measured by light, but weight still has to be measured against a reference weight. Today's range of weighing equipments include balances capable of weighing an counting up to ten thousand different types of parts and scale that can be programmed to weigh price and label goods. [3]

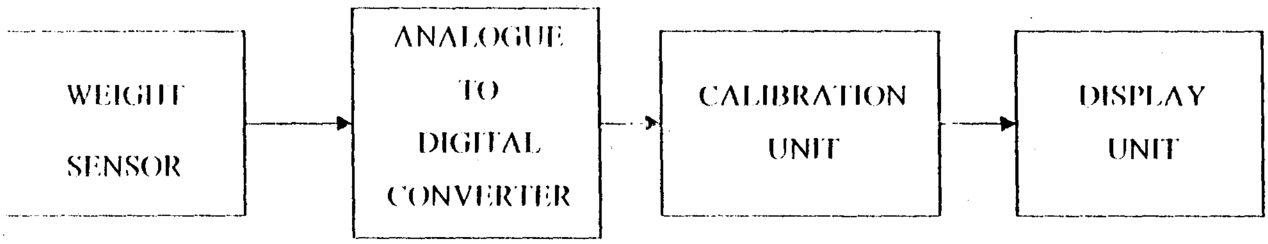

Fig.2.1: Simple Design concept of an electronic weighing machine

2.2 TYPES OF WEIGHING MACHINES

Weighing machines are grouped under load capacity, complexity, accuracy and mode of operation. Spring scales are good and simple examples. They measured force which can be measured in units of force such as Newton or p0ound – force. Spring scales typically cannot be used for commercial purpose unless their springs are used at fairly constant temperature location. They can give an accurate measurement in Kilogram.

In strain gauge scales, the deflection of a load beam can be measured using gauge which is length – sensitive electrical resistance. The capacity of such devices is determined by the resistance of the beam to deflection and the results from supporting locati0ons may be added electronically. Therefore, this type of measurement is especially suitable for determining the weight of very heavy objects such as trucks, and trailers, as is done in a modern weighbridge. 2]

A more duty type is the Hydraulic or Pneumatic scales; they are common in high – Capacity applications such as crane scales, which used applied to a piston or diaphragm and transmitted through hydraulic lines to a dial indication. Based on a Bourdon tube or electronic sensor. [2]

Modern types involve electronic digital force measuring instruments which can be hand – held or mounted in a test stand and are suitable for tensions and compression testing in capacities from 500g to 500Kg. these accurate and easy – to – use test instruments greatly assist industries to improve quality control in production. Compact electronic sensors have allowed the design of low profile digital platform scales. These machines are available in sizes, typically ranging from 200 X 1200mm to 1800mm X 1800m with weighing capacity ranging from 600 to 600Kg. One of the main advantages of this type is the low profile platform. [3]

2.3 PREVIOUS WORK

Weight system was first used by the ancient Egyptian and Babylonian at about 500BC. It consisted of a simple beam system which is pivoted at a point with a standard weight at the in one pan and the unknown weight at the other point. [4]

The Romans improved on this when at the pivoted point, they fixed a triangle section to the beam to increase the accuracy and sensitivity of the system. This was called equal arm balance. [5]

Alchemists and Assayers, who were inventors in the sixteenth and seventeenth centuries. Turned their attention to the evolution of knife – edge as a pivot for balance. One of the the earliesty recorded representations of knife – edge is the famous portrait by Hans Holbeing, the Hanseatic merchant.

Three triangular knife – edges were incorporated. One is located at the centre of the beam, with its apex pointing downward and was acting as a pivot. The other two at the beam ends with their apexes pointing upwards from which the scale pans were suspended. This was an improvement over the Romans equal arm balance. However, friction between knife – edge and their bearings still reduced accuracy.

One of the first accurate and self – indicating scales for industries was developed in the latter part of the 19^{th} century. This revolutionilzed the weighting process. Loss of weights and poises were eliminated in these machines, which gave an almost instant indication of weight of goods. Pendulums were applied such that weight from the scale beam, via a cam or pulley allowed a pointer to transverse the chart and indication the chart and indicate the weight. [2]

Another innovation was that of Avery Dial recorder which fitted to industrial weighing machines. These machines printed a fraud – proof record of all goods weighed on the scale. The reading of the weight also had the advantage of being much easier to read than hand written notes. [1]

From the late 1940s mechanical weighing system began to combine with electronics. But this was not so until load cell and digital electronics were introduced to weighing systems. This invention replaced complex and bulky lever system and knife edges for more accuracy and acceptability. [2]

Because gravity varies by over 5% over the surface of the earth, [2] the distinction between weight and mass becomes relevant for accurate calibration of scales for commercial purposes.

Traditional mechanical balance – beam scales intrinsically measured mass. But ordinary electronic scales measure the gravitational force between the sample and the earth i.e the weight of the sample [3]

CHAPTER THREE

CIRCUIT DESIGN AND IMPLEMENTATION

3.1 DESIGN ANALYSIS.

The project comprises the following units:

- Power unit
- Input /sensor unit
- Analogue – to - Digital converter Unit
- Calibration /display unit

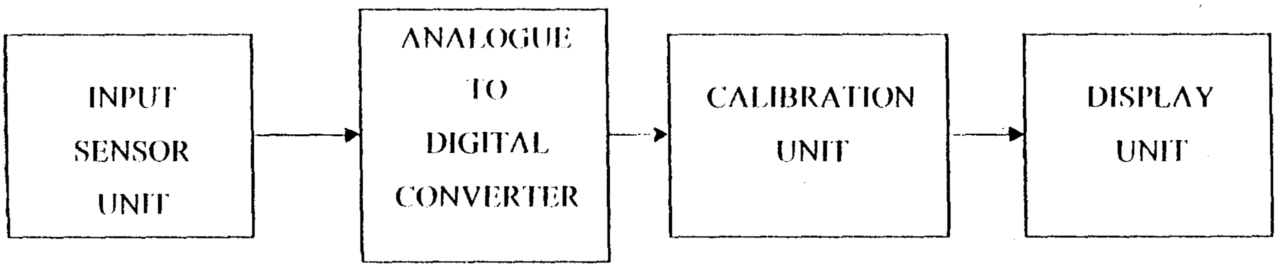

Fig 3.1 Block Diagram

3.2 POWER UNITS

The power supply is based on a 12V A.C 500mA output step down transformer. The device steps down the 220V A.C main supply to roughly 12V A.C. After rectification of the voltage, two voltages are attained for the complete circuit. A 7805 (5V regulator) provides regulated 5V power for the involved integrated circuits.

3.2.1 Transformer

The turn's ratio of a transformer in a D C power supply can be selected to either increase or decrease the 220V ac input. With most electronic equipment, a supply voltage of less than 220V is required and therefore a step down transformer is used. The secondary output voltage (V_S) from the transformer can be calculated with the formula below.

$$V_S = \frac{N_S \times V_P}{N_P}$$

Where

V_S = Secondary voltage of transformer

V_P = Primary voltage of transformer

N_S = Secondary winding of transformer

N_P = Primary winding of transformer

3.2.2 Rectifier

The rectifying unit is used to change or convert the a c voltage from the transformer's output to d c voltage used by the circuit. There are two types of rectification: the half wave rectification and the full wave rectification. The full wave rectifier consists of four diodes which only allow current flow in one direction. The full wave rectifier was chosen for this project because its output can easily be filtered to a smooth d c level as against the half wave rectifier unit .See bridge rectifier below.

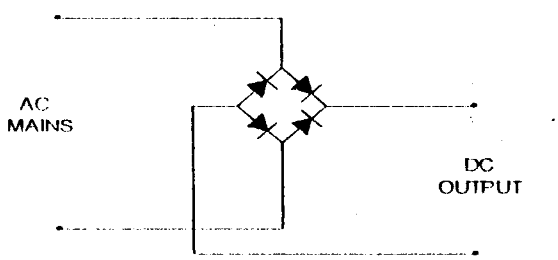

Fig 3.2 The Bridge Rectifier Circuit

Rectifiers are now available in IC forms for easy construction work. The output of the transformer after rectification gives a waveform output which is the full wave rectification output waveform.

3.2.3 Filter Capacitor

Filtering in a d c Power supply converts the pulsating d c output from the full wave rectifier into an unvarying d c voltage. When the ac input swings positive, the diode is turn on and the capacitor charges, but the charges times' constant will be small because no resistance exists in the charge path except for that of the resistance of the connecting wires. When the ac input begins to fall from its positive peak (at 90^0) the diode is turn off by the large positive potential on the diode's cathode being supplied by the charge capacitors, and the decreasing positive potential on the diode's anode being supplied by the input. With the diode off, the capacitor begins to discharge. The discharge time is a lot longer than the charge time because of the load resistance. As the ac input and the rectifier's pulsating d c cycle repeat the output (V out) is an almost constant d c output with a slight variation or ripple above and below the average value.

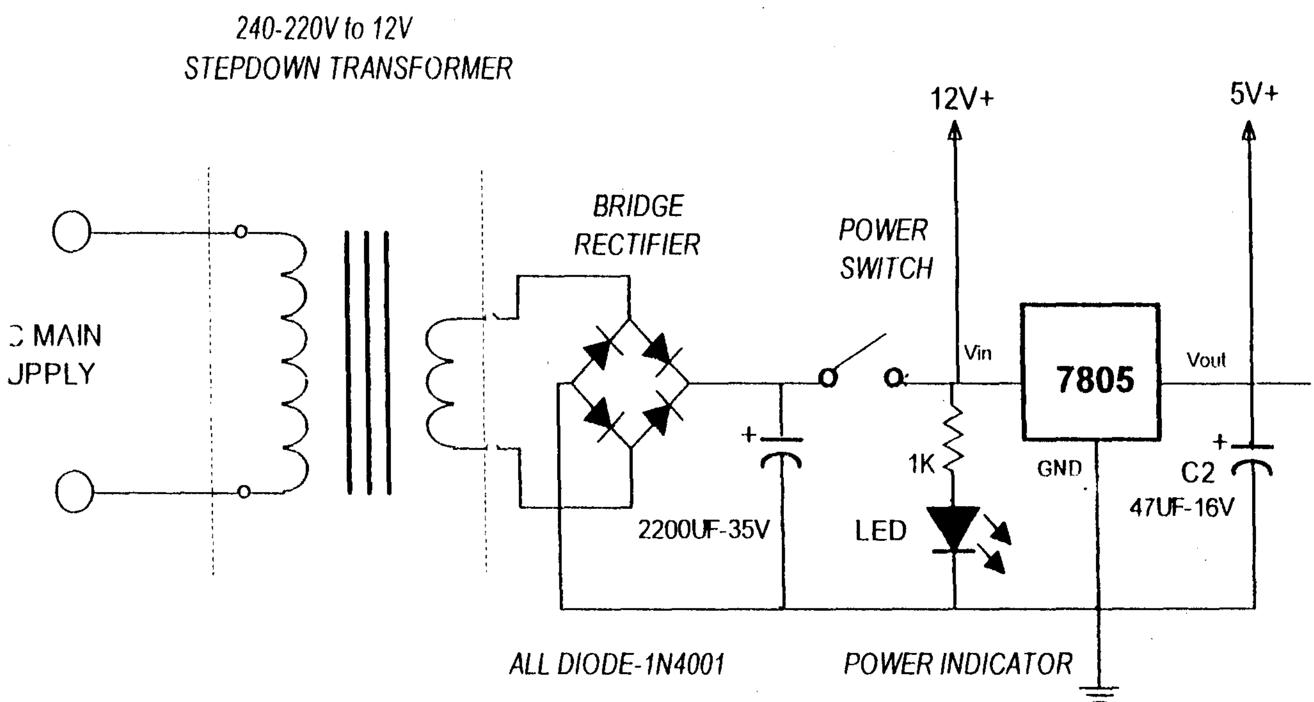

Fig. 3.3: The power unit

The 12V supply only deals with the display. This is due to relatively high electric current for the involved LEDs. A common bridge rectifier comprising of four rectifying diodes is the base of the power conversion. The diodes serve in converting the 12V AC into corresponding 12V D.C. The leading connection allows only two of the diodes to be active or forward biased at a particular half-cycle of the alternating voltage [1].The devices direct the negative and positive components of the alternating current to separate terminals or points. Therefore, a polarized output is given form the configuration.

The output from the rectifier is expected to be fully D.C. But, this is not always true. The voltage is attributed to ripple, a signal of small component of the A.C input. The frequent way of removing the unwanted feature is the use of a polarized or electrolytic capacitor with a range of 1000-3300µF. A 2500µF of 25V capacitor is the choice for the project. The voltage rating of 25V of the capacitor is chosen away from the expected peak voltage of the circuit.

The 7805 IC is connected in the output terminals of rectified and filtered D.C voltage. A LED circuit is used to indicate the presence of electric power in the circuit.

3.2.1 Power Indicator

The circuit involves a resistor and light emitting diode (LED). The resistor allows a voltage drop of around 2.7V across the light indicator.

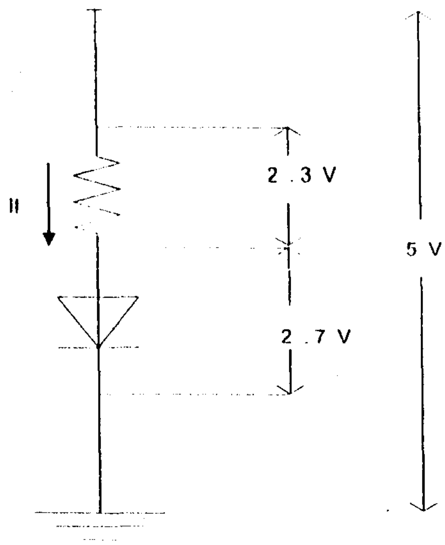

Fig. 3.4: The power indicator circuit

A typical current (It) of 2.5mA is expected flowing in the series connection [2].

Therefore, the likely value of Rt is given below: -

$$Rt = \frac{2.3}{2.5 \times 10^{-3}}$$

Rt = 766.651Ω

A 1KΩ resistor is used in the circuit

3.3 INPUT/ SENSOR UNIT

The input unit is the weight sensing part of the altogether circuit. It is designed with a variable resistor. The weight measuring technique involves the application of a stable voltage across a potential divider with the weight sensing resistor in which the voltage across it directly varies with applied weight.

That is,

Using ohms law: $V \propto I$ when resistance is contact

Voltage = V

Current= I

At a constant current, $V \propto R$

That is the greater the resistance the more voltage across.

Moreover,

$$R = \frac{\rho L}{A}$$

$$R \propto L$$

Resistance (R) is directly proportional to length (L) [1].

The displacement in length is caused by the measuring weight. This displacement is proportional to a particular voltage.

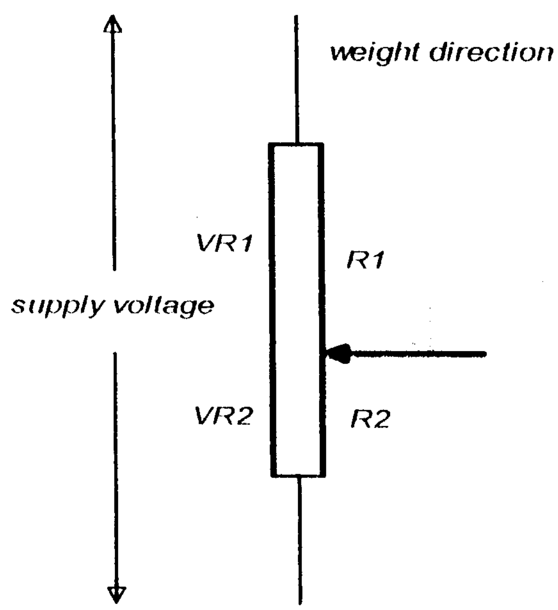

Fig. 3.5: The Weight Sensor/Potential Divider

$$V_{R1} \propto R_1$$

$$V_{R2} \propto R_2$$

The voltage across R2 (VR2) is used to define the weight in the circuit.

From design experiment the sensitive voltage of the weight machine is suitable at 0.0113V or 11.3mV.That is, every 1Kg measuring results into 11.3mV increment at the output of the potential divider. A conventional weighing machine or scale, in which this project is adapted from, is attributed to a maximum weight capacity of 120Kg.

Therefore, the full voltage range is:

Maximum Weight × Voltage/weight Sensitive

$$120 \times 11.3 \times 10^{-3} = 1.36V$$

This is the full voltage expected at the concerned resistor. That is,

$$V_{R2} = 0$$

$$V_{R1} = 1.36V$$

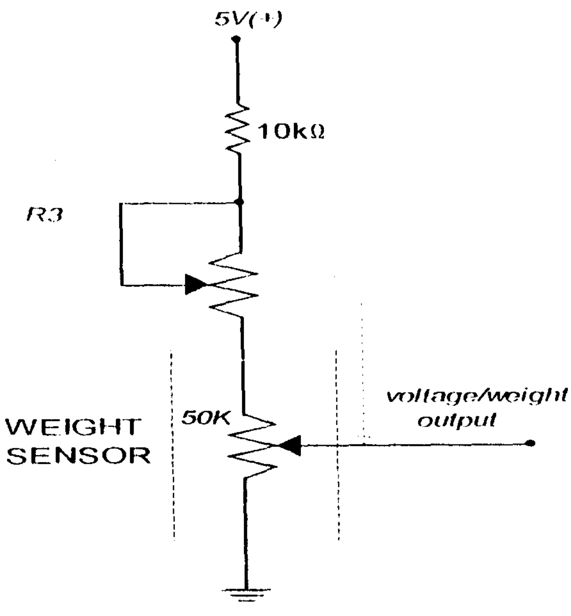

Fig. 3.6:The Input Potential Divider

The voltage across R3 is:

V_{cc} − Voltage across the weight sensor

The VR3 is

$$5 - 1.36 = 3.64V$$

The electric current through the weight sensor is

$$\frac{1.36}{50 \times 10 \times 10^{3}} = 27.2\mu A$$

Therefore, R3 is:

$$\frac{3.64}{27.2 \times 10^{-6}} = 133823.5\Omega$$

R3 is the combination of two resistors a 10KΩ and a 200KΩ variable resistor. The variable resistor is used to properly adjust R3 to a suitable value.

The output of the potential divider is connected to the ADC unit so as convert the corresponding voltage of the input weight to binary code in 8-bit. [7]

3.4 ANALOGUE – TO - DIGITAL CONVERTER UNIT

The, ADC0804 is a CMOS 8-bit successive approximation A/D converter. It converts a certain analogue signal or voltage into corresponding digital codes. It uses a differential potentiometer ladder D similar to the 256R products. The converter is designed to allow operation with the NSC800 and INS8080A derivative control bus with TRI-STATE output latches directly driving the data bus. The A/D appears like memory locations or I/O ports to the microprocessor and no interfacing logic is needed. Differential analog voltage inputs allow increasing the common-mode rejection and offsetting the analog zero input voltage value. In addition, the voltage reference input can be adjusted to allow encoding any smaller analog voltage span to the full 8 bits of resolution [8].

Although, designed for the application with micro-processors, the ADC0804 was successfully adapted for the project. It merely converts the output signal or voltage from the sensor to corresponding binary codes for display purpose.

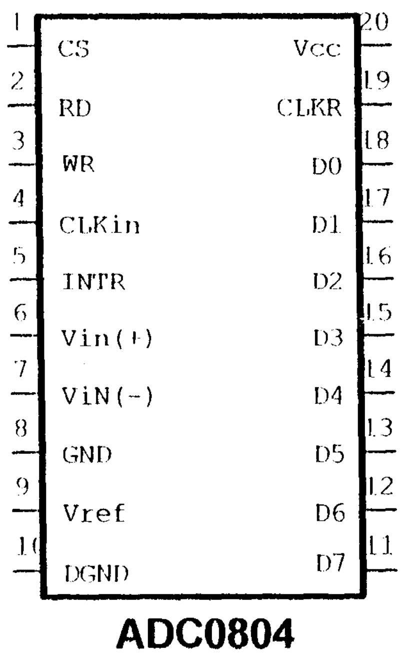

Fig. 3.7: Pin configuration of the ADC0804

D0-D7 are the binary outputs representing a particular analogue signal from both pins 6 and 7.Pins 2 and 19 deal with the operating frequency of the device. These points deal with a RC oscillator set-up [8].

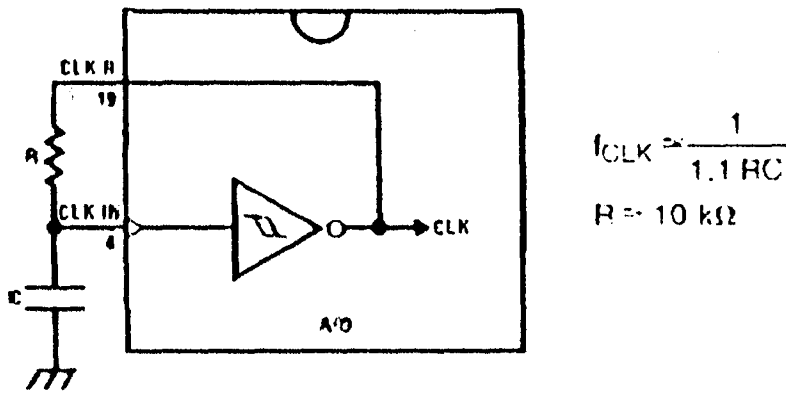

Fig. 3.8: The RC oscillator of the ADC0804

The manufacturer of the ADC0804 advises the use of 150pF for C and 10KΩ for R.

Therefore, the frequency of operation is given below [8]:

$$f = \frac{1}{1.1\times 10\times 10^{3}\times 150\times 10^{-12}} = 606060.6Hz$$

Moreover, the ADC operates with a speed of 606.6 KHz

Therefore the operation period is given as:

$$T = \frac{1}{f} = \frac{1}{606060.6} = 0.00000165s$$

The ADC operation timing is given as 1.65μs.

Pins 1, 2, 10, and 8 are normal ground. Pins 3 and 5 are connected together. The device works with the 5V output from the power unit.

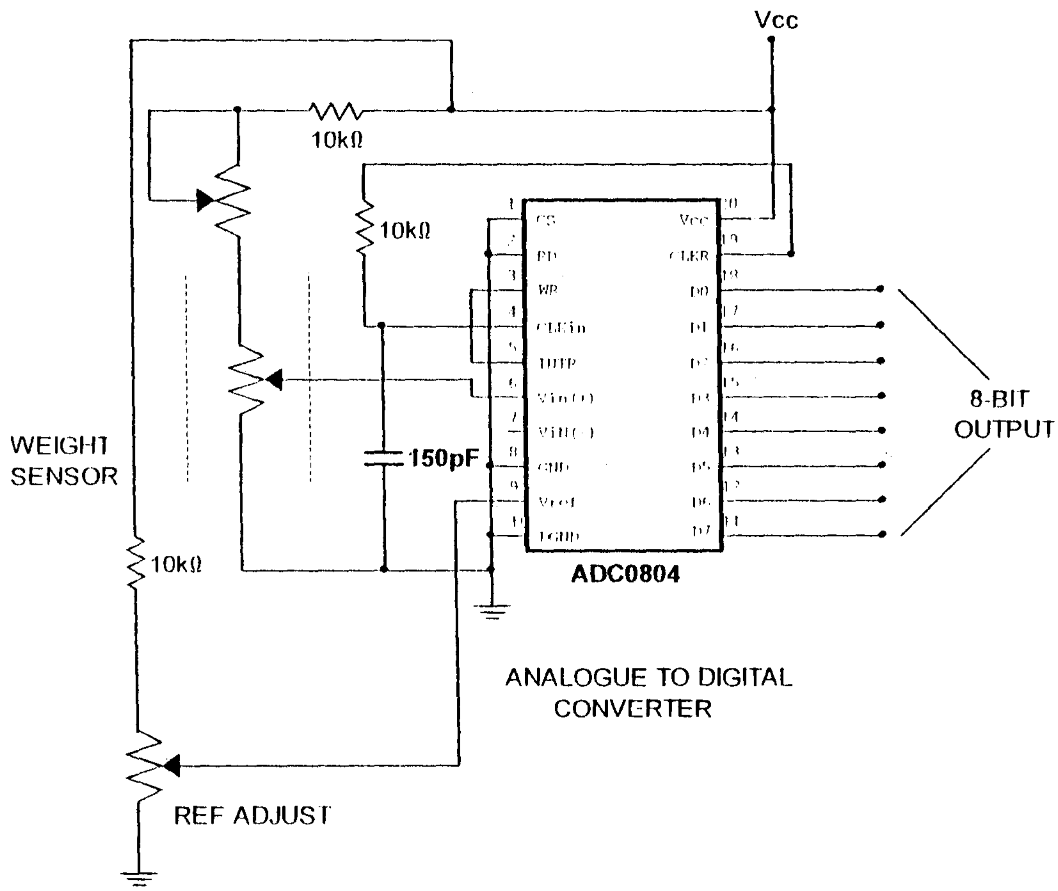

Fig3.9: The ADC circuit

The circuit is specified by the datasheet of the integrated circuit. Pin 9 is used to adjust a particular voltage [8].

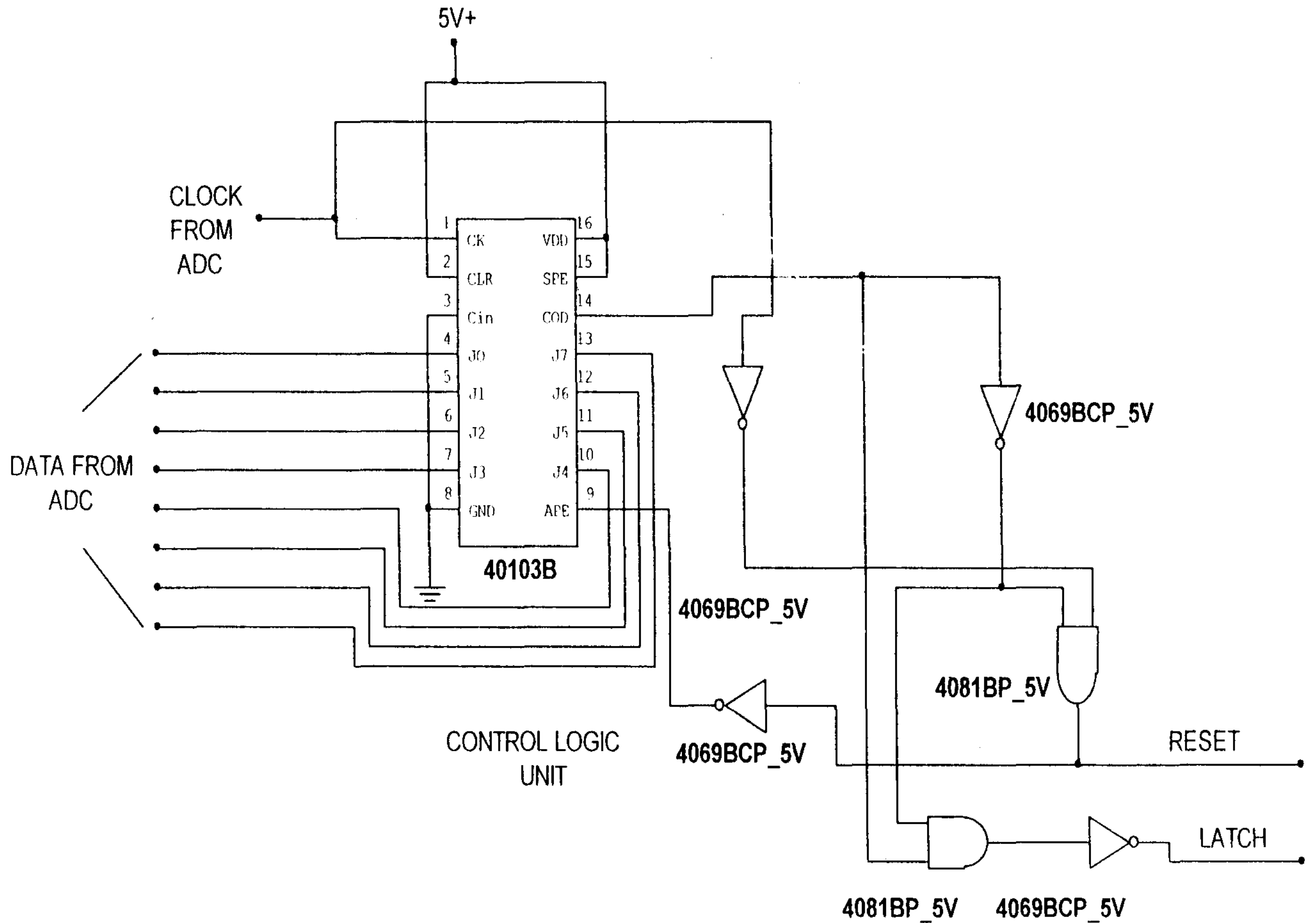

Fig3.10 The full Analogue/Digital Converter unit

The AND-NOT gate circuit i.e logic circuit is designed to interact with the ADC with the output part of the circuit. The 40103B is a down counter that works at the same clock rate as the ADC and the display counters for the production of a display result.

Two main controls are fed to the display unit through the AND-NOT gate logic. They are "latch" and "reset" commands. The display decoders, involving the 4511B integrated circuits, are fitted with latches or memories that store the initial display result before a new value is achieved and ready for display. The reset logic control clears the display counters after their value is stored into the memory. The operation goes into a high speed cycle. [10]

3.5 DISPLAY UNIT

This unit is designed to convert the information for weight from the ADC to a visual format. This unit mainly consists of the 4518B and 4511B Complementary Oxide Semiconductor (CMOS).

3.5.1 4518B

The 4518B is a dual BCD UP counter. In other words, it is a single integrated circuit which holds two independent BCD Up counters. Each counter possesses internal synchronization stage. Therefore, they provide a good clocking response. The counter stages are D-type flip-flop having interchangeable clock and ENABLE lines for incrementing in either the positive or negative transition of the clock. The counters are cleared by high levels in their RESET terminals. The counters can be cascaded in the ripple mode by connecting Q_4 to the ENABLE input of the subsequent counter while the clock input of the latter is held low. The medium-speed operation is typically 6MHz [5].

The 4518B is mainly used for multi-stage synchronous counting, multi-stage ripple counting and frequency divider applications.[11]

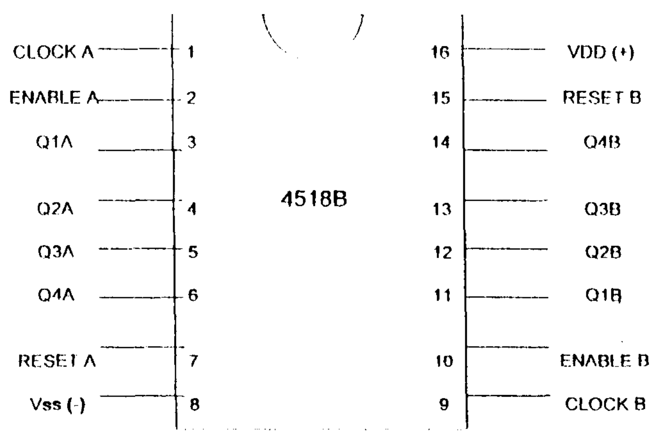

Fig. 3.11: pin Assignment of the 4518B IC

Table 3.1 The Truth Table of 45118B

CLOCK	ENABLE	RESET	ACTION
↑	1	0	Increment counter
	↓	0	Increment counter
↓	X	0	No change
X	X	0	No change
↑	0	0	No change
1	↓	0	No change
X	X	1	QA to QB =0

X =don't care, 1 =high state, 0 =low state.

3.5.3 4511B

The major component of the display unit is the 4511B integrated circuit. The 4511B is a 16-Pin CMOS latch/BCD to 7-segment decoder integrated circuit. It is designed with bipolar outputs for high current rating displays or loading application [8]. The device possesses both lamp test (IT), Blank (BL) and Latch Enable or Strobe inputs for testing the display, shutting off and intensity-modulate it and storing a BCD code respectively. Several different signals may be multiplexed and displayed when external multiplexing circuitry is used. The integrated circuit is only compactable with common-cathode 7-segment display. This load is attributed to lower power consumption as compared to common anode type.

The lamp test (LT) and Blank (BL) terminals are usually made positive or high logical level during normal operation. The latch/strobe input is ground or logic 0 during this condition. The device is designed for BCD inputs. Therefore, it blanks a display whenever unrecognizable codes are fed into the input [6].

Table 3.2 Code Display Table of 4511B

CODE	DISPLAY
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9

3.5.4 Common Cathode 7-segment Display

The weight display involves three red LED common cathode displays. Their segments are made of three series connected LEDs. The construction resulted into a relatively large display for good visibility as compare to the commercially available ones.

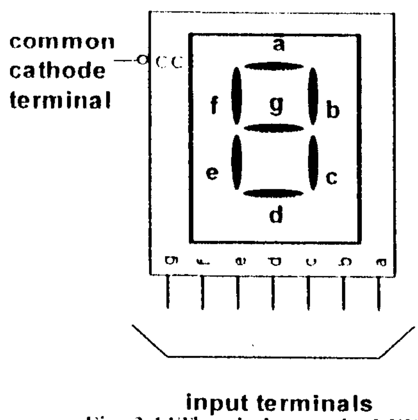

Fig. 3.11 The pin layout the LED 7-segment display

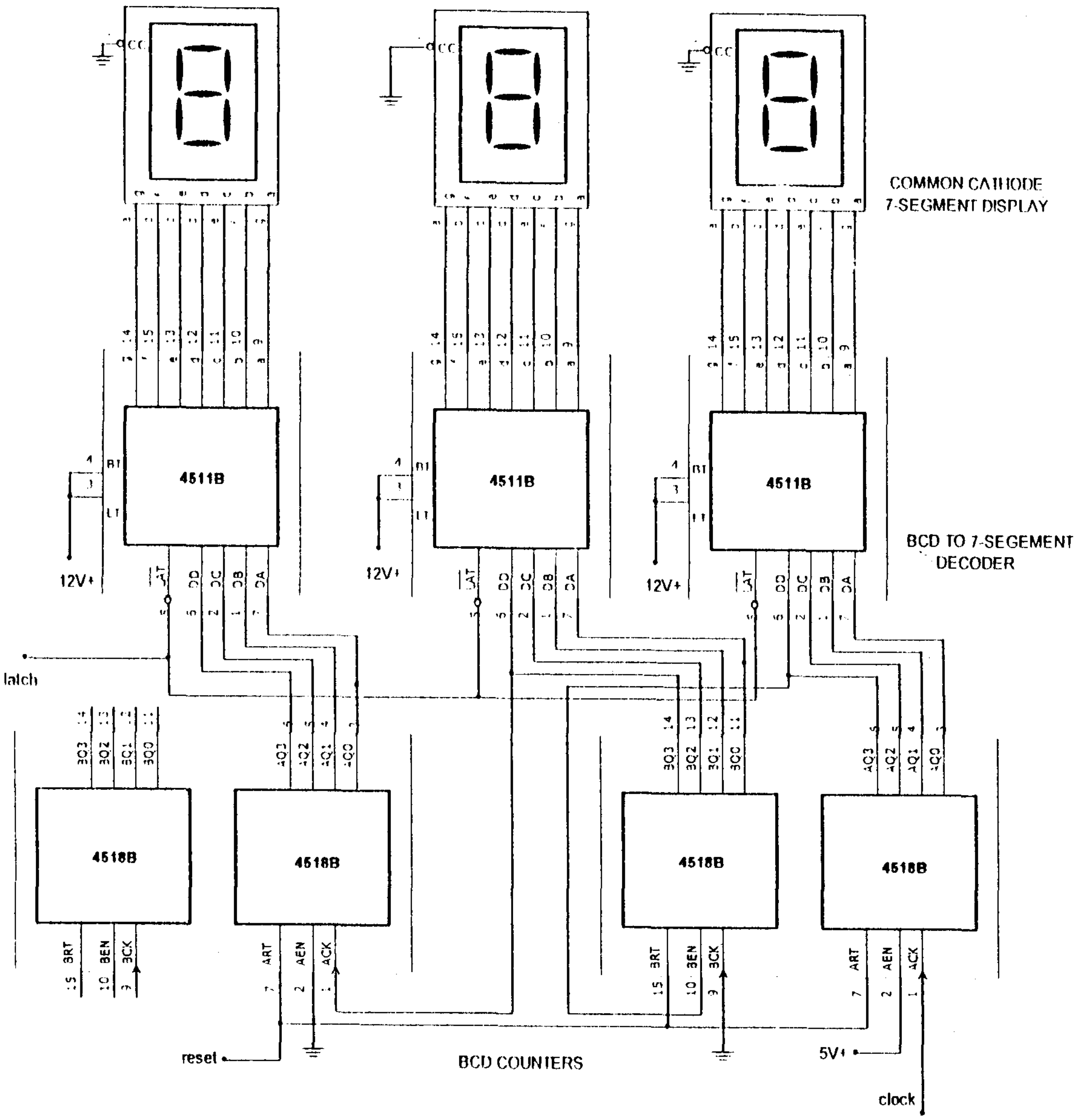

Fig. 3.12:The full display unit

CHAPTER FOUR

CONSTRUCTION, TESTING AND RESULT

4.1 CIRCUIT CONSTRUCTION

The circuit construction was made directly on a Vero. This is because of assurance of the design. The active surface of the Vero board was properly scrapped for easily soldering. Moreover before the involved integrated circuits were mounted on the Vero board, corresponding IC sockets were soldered into their respective positions. The involved sockets are protective devices for the integrated circuits which easily respond to heat for soldering iron.

The other components such as resistors, capacitors and LEDs are soldered directly to the board. The most tasking art of the construction is he display. A total of 63 red LEDs were soldered to form 7-segment displays.

In fact, the circuit altogether was made in modules. Each module was independently tested; then latter connected together. The connection was done with utmost care in order to avoid short circuits, especially at power terminals.

The main precaution during construction is avoiding power short circuit.

4.2 CASING CONSTRUCTION

The casing of the circuit involves a plastic part from house power supply unit. It was modified to fix the purpose of the work. The case of a commercially available mechanical weighing machine is also in use to safe cost. The two is connected together through a cable from the weight sensor. The LED display is exposed through a transparent .plastic.

4.3 TESTING

The testing of the involved circuit or set-up was carried out to justify the workability and accuracy of the project before it is concluded a success. The testing was carried out with reference to commercial mechanical weighing machine or scale, it is necessary for reason of calibration.

Moreover a person weight (69Kg) was known through a mechanical weighing and it is calibrated on the project. The calibration is quite easily because of the linear nature of the involved weight senor.

After the calibration, many known weights were weighed with the project.

4.4 RESULTS

Table 4.1 Results obtained from the Testing

S/NO	Weight in Kg on mechanical weighing machine	Weight in Kg on digital weighing machine
1	69	69
2	60	62
3	55	56
4	53	52
5	48	50
6	40	40

4.5 DISCUSION OF RESULTS

The result showed that the difference in measurement from the project and other commercial available mechanical weighing machines is quite small or negligible. The measurement error is due to the sensor placement. The error is sometimes one or two Kilogram which is a quite acceptable by the standard of this work.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The project simply demonstrates the significance of electronics in measurements. The steps of interfacing and Analogue – to – Digital Conversion (ADC) with other logical devices without the use of microcontroller are of great importance to this work. Although the sensor in use is not of industrial standard, the main aim of the work was achieved through it.

The success of this work is attributed mainly to the acquisition of relevant information such as the involved integrated circuit manufacturers' data sheet

5.2 PROBLEMS ENCOUNTERED

i. The multiple reading errors were quite a problem before the logic control unit was modified to bridge over the problem.

ii. Instability of current was a problem initially but it was later overcome by incorporating Voltage regulators into the design to remove the current instability.

iii. Also, the unit was required to be shielded from external light source, this is important in order to increase the accuracy of the device.

iv. The acquisition of components used was initially difficult. Later most of the components were gotten from Lagos.

5.3 RECOMMENDATIONS

i. The project could be modified for computer interfacing applications with relevant software.

ii. More integrated electronic components could be interchanged for the ones used for reasonable compatibility.

iii. A better sensor could improve the accuracy of the measurement.

iv. The design could be modified for large weight range.

v. The display could be made of Liquid Crystal Display (LCD) instead of Light Emitting Diode (LED) for lower power consumption.

vi. A battery package could be incorporated.

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APPENDIX 1

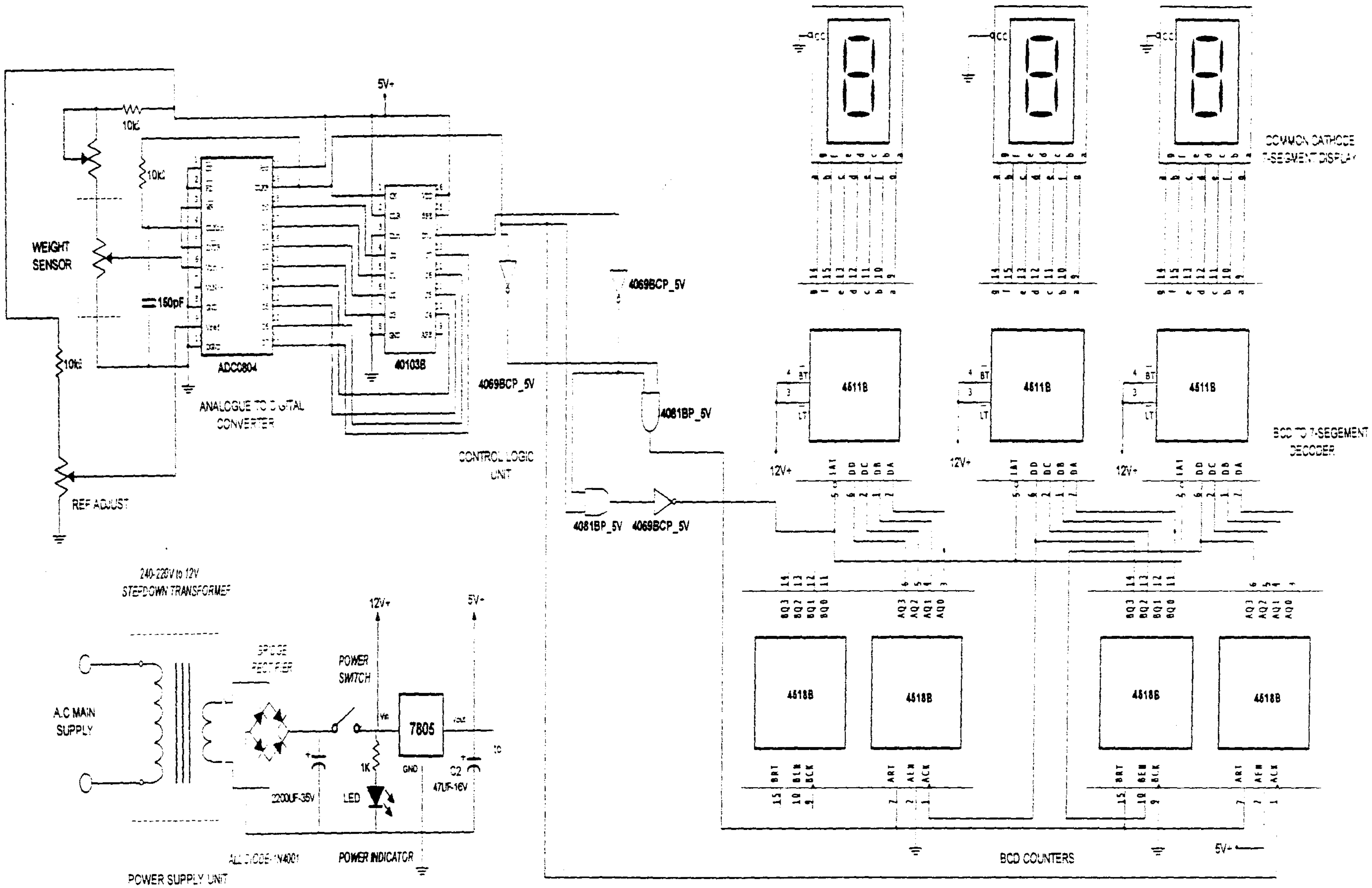

Fig 5.1: Complete Circuit Diagram of Digital weighing Machine

USER'S MANUAL OF DIGITAL WEIGHNING MACHINE

DESIGNED AND CONSTRUCTED

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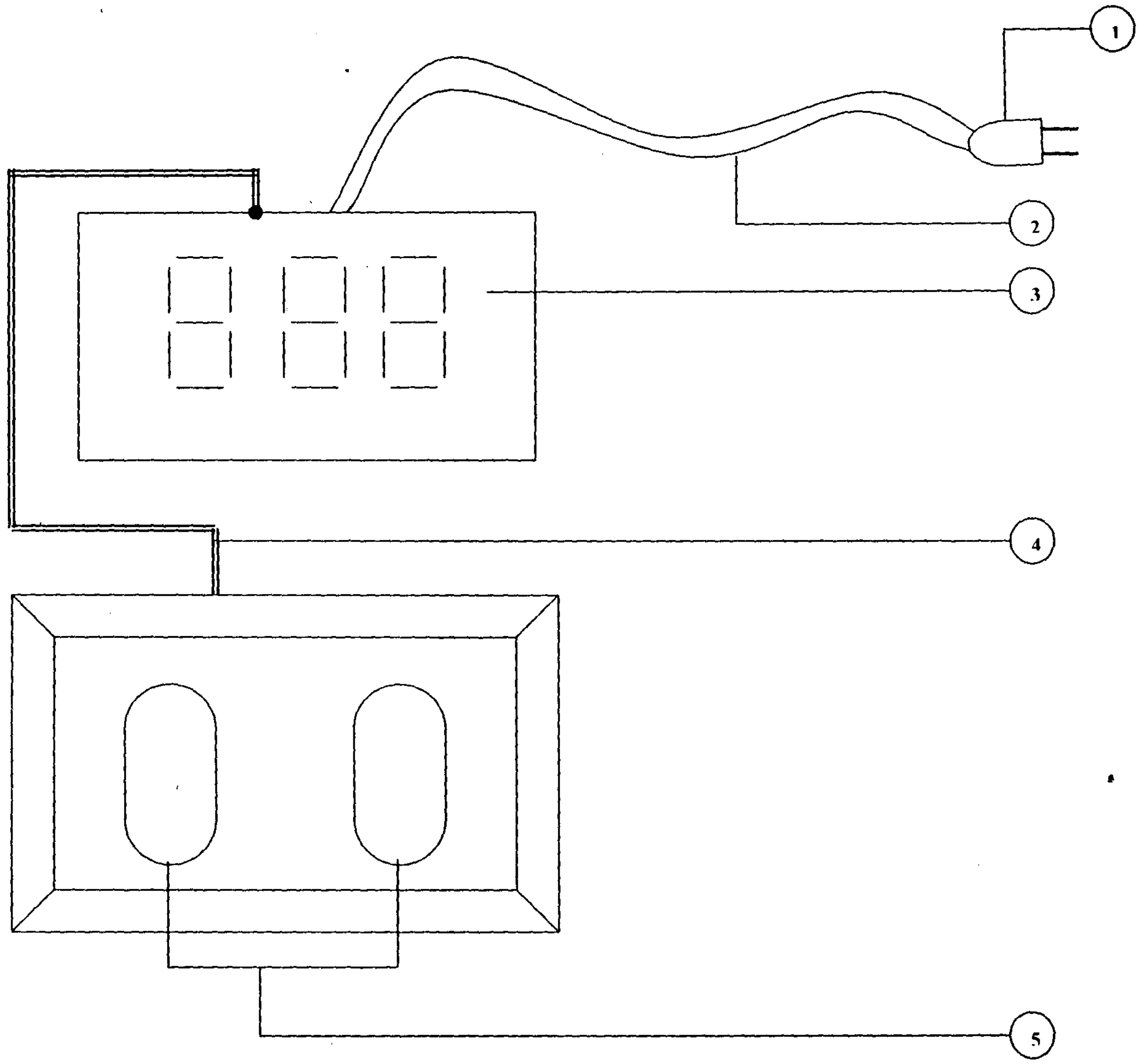
USER'S MANUAL



Digital Weighing Machine Diagram

LIST OF PARTS

1. Power Cord Outlet
2. Power Cord
3. Digital Display Panel
4. Sensor connector
5. Weight exerting Area

HOW THE MACHINE WORKS

When the weight is exerted on the device it causes displacement which is made into voltage by the weight sensor. The voltage is being converted by the ADC into a binary code equivalent which is calibrated and being display in kilogram

HOW TO OPERATE THE DEVICE

- Plug the power cable to the a.c source
- The display comes up indicating the presence of power
- Exert the weight on the weight exerting area of the machine
- Then the measured weight is displayed

TROUBLESHOOTING

- When the device fails to display when connected to power source, the contact with the power source should be checked if well connected.
- When there is no weight on the system and it displays certain value, unplugged and re-plug
- Ensure that device is powered by 220V a.c and the problem persist see a quailed technician
- On a normal condition when the weight is removed the reading returns to zero but when it is fails to return to zero shake the weight pan and if the problem persist see a qualified technician.

WARNING∆!

- Do not short circuit
- Ensure that a.c source is used to power the device
- Do not open the case when the device is powered