DESIGN AND CONSTRUCTION OF DIGITAL CALIPER

BY

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DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

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NOVEMBER 2004

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A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA. IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN ELECTRICAL AND COMPUTER ENGINEERING.

NOVEMBER 2004

CERTIFICATION

This is to certify that I have supervised, read and approved this project report which I found adequate both in scope and quality in partial fulfillment of the requirement for the award of bachelor of engineering degree in Electrical and Computer Engineering.

Engr. T. Asula Project Supervisor	15.12.2014 Signature/Date
Engr. M.D. Abdullahi Head of Department	Signature/Date
External Examiner	Signature/Date

DECLARATION

I hereby declare that the project work is an original concept wholly carried out by me, under the supervision of Engr. T. Asula of the Department of Electrical and Computer Engineering, Federal University of Technology, Minna.

Tola James o.

Name

8-12-2004
Date

DEDICATION

This project is dedicated to the Lion of the Tribe of Judah, the Lord of Lords, King of Kings, Prince of Peace, and the Almighty God.

ACKNOWLEDGEMENT

My profound appreciation goes to Almighty God for his guidance bestowed on me and for making me part of history in the Department of Electrical and computer Engineering.

I also express my profound gratitude to my Uncle, who is a father Engr. S.O. Balogun, who give me a beginning and courage to forge towards an end and under whose guidance and support I have been able to attain this level.

A million appreciations also goes to my brother Engr. Cyril K. Ogidefa whose effort in ensuring that I got to this stage in life is immeasurable.

I'm greatly indebted to my supervisor, in person of Engr. T. Asula, under whose guidance and corrective criticism I was able to accomplish this enormous challenge posed by this work. To him I am indeed most grateful.

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My acknowledgment goes to those who have in one way or the other contributes to my huge success. In this regard, I am most indebted to Mr. & Mrs. Jacob Aluko, Hajia Bilikisu Inua, Mr. & Mrs. Terry Maka, Mr. Jerry Maka.

Tola James O.

ABSTRACT

The design analysis, construction and testing of a digital caliper is presented in this project work by applying the appreciation of the techniques used to convert a direct analogue voltage to a digital display via the Analog-to-digital conversion (ADC) techniques. The techniques employed were based on voltage generated from the variable potentiometer and feed into the ADC, which convert analog signal to digital word and to the display unit with the help of a common - cathode LED.

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CHAPTER ONE

1.0: GENERAL INTRODUCTION

1.1: INTRODUCTION

An engineering measurement is the comparison of the size of an object or the feature in an object with a legally defined unit or a standard value. It has to be generally accepted unit.

The basic unit of length in the system international (SI) is the metre. It is defined as equal to 1,650,763.73 wave length of the radiation emitted by the gas krypton (Isotpe86) in a vacuum. The emission is an orange light of a very precise wavelength. The metre is subdivided into 1000 equal divisions and each division is called millimeter.

Measurement of voltage using a D.C resistance potential decider is achieved by a high-non inductive resistance, across which a small portion of it is attached to a voltmeter. Wheat Stone Bridge is another means of measuring voltage by comparison process and resistance value may be determined by comparing voltage drops across known and unknown resistor. Venire caliper and micrometer screw gauge can also be used to measure the length, thickness and diameter of an object.

The above mentioned methods and instrument for measuring voltage and length are good in producing the result with the least uncertain a greater amount of skill experience and absolute seriousness of the user. In addition they are clumsy, meticulous in handling and the time required to perform the measurement may be quite large.

Therefore, the need for a digital instrument with certain features like the ease in reading the output, time saving, simple, direct and handy to use is very essential The aim of this project work is to design, construct and test a viable digital caliper that satisfies all the above requirements.

1.2 PROJECT OBJECTIVE AND MOTIVATION

Digital instruments are intelligent instruments that can make decisions, based on previous readings, manipulate information, process values and initiate action based on the results of these abilities.

They have certain feature that makes them very attractive for certain application. These are, the ease in reading the output, digital coded output, which can be feed directly to a digital computer.

Also they are simple, direct, and handy and time saving. In view of the above mention qualities of digital instruments, I decide to build a digital caliper that will have almost all the qualities of a good digital instrument.

It will measure length, diameter or thickness of an object in centimetre, with accuracy of $\pm$ 0.1cm, digital display of measurement and with little power consumption.

The CMOS integrated circuit IC has been considered most suitable for the construction of the digital caliper because of low power consumption (5 to

15v), better noise immunity (1.7v), simple internal circuitry and the ability to operate on an inexpensive non-regulated power supply.

1.3: LITERATURE REVIEW

The first measurements were made in Egypt about 3500BC. The reason was to measure the rise and fall of the nile in order to effect efficient irrigation and water management.

The early Egyptians defined one finger width as a zibo and established the relationships:

100 zebos	=	1nent
10 nents	=	1knent
10 knents	=	1 cable length
10 cable length	=	1 thousand

This was the advent of the decimal system of country. And note the use of human dimensions as the first standard.

Over the years, these measurement spread. For example the Phoenicians (Lebanon) use half-seized Egyptian measured. Two design philosophies emerged.

1) "A unit of length would be selected, the cube of which gave a measure for capacity; the weight of cool water contained in it gave the unit for weight"

2) When arithmetic and the art of metrology were in their infancy and their mysteries understood by a few, it was essential: 'To be able to express the basic quantities of length, area, volume and weight in their commonly occurring magnitudes without the use of fractions or very large numbers; and to be able to measure these quantities simply and accurately.

For thousands of yours, these were a way people measured comparatively short distance. In 1672, Sir Isaac Newton presented the world with new ideas on the nature of light and colour. He had noticed that when two flat pieces of glass were pressed together, he could see circular bands of rainbow like colours. These were called Newton's Rings. Actually, Newton had come upon a very precise method of measurement, but he didn't recognize it as such at that time. Later, other scientists were to build on Newton's seminal finding and establish a new branch of science called interferometry.

Today this method of using a ray of light as a measuring stick enables man to measure distance within millionth of an inch or millimeter.

Charles Augustin de coulomb (1736 - 1806), French physicist, is a pioneer in electrical theory. In 1777 he invented the torsion balance for measuring the force of magnetic and electrical attraction. With this invention, coulomb was able to formulate the principle, now known as coulomb's law, governing the interaction between electric charges. 1779 coulomb published the treatise "Theorie des machines simples" (theory of simple machines) an analysis of friction in machinery. After the French revolution, coulomb came out of retirement and assisted the new government in devising a metric system of weight and measures. The unit of quantity used to express electrical charge, the coulomb was name after him.

In the field of measurement, Edward Weston (1850 - 1936) developed three important components: the standard cell, the Managing resistor and the electrical indicating instrument. Weston was both an inventor and an entrepreneur.

The metric system spread to all countries under French influence during the Napolenic periods and imperial measures stopped developing, except the Therm. Gauss suggested using a few basic units and relating the rest to them. And so the system was developed. Scientists used the decimal system more than the Engineers as Engineers dislike the smallness of the units (for example energy was /erg where 10 million ergs equal 1Joule) and in 1954 the mks system was agreed and then in 1960 the SI unit system became accepted.

Measurement is the process of empirical objective assignment of numbers to the properties of objects and events of the real world in such a way as to describe them.

When a number characterizes the property of an object or event, this carries information about the property. Modern technology has made immense strides in the development of instrumental means of information acquisition from physical objects and events. The information is encoded in the form of a physical signal and can be output in the form of a number representing a physical signal and can be processed by a variety of information machines. The information can be output in the form of a number representing a physical property, in other word a measure. These powerful modern means of information acquisition and processing constitute the nerves and brain of an immerse variety of modern technical systems for measurement.

Although, electricity was the most recent technological discipline to develop, it was rapidly found to be the most appropriate for any tasks required in a measuring system. Certain classes of instrument can be constructed without recourse to electrical principles, examples being the microscope, the micrometer screw gauge, venire caliper, the direct recording water level gauge and many more. However, if the application needs extensive information, processing, signal transmission over a long distance, uniformity of manufacture at ow cost, very powerful processing and data handily ability.

Electrical techniques includes both the traditional electrical and the more recent electronics discipline. The distinction between the two is usually based on the premise that both are concerned with electron flow, the former being a macro-level, the later at the discrete electron level; this is some what artificial in modern terms of application.

Electrical quantities like voltage, current and resistance are measured by many instruments. Most of which are analogue in nature (pointer). Through the advancement development in modern electronics with special interest in digital applications, the digital form of the measuring instruments are made possible by employing the users of modern integrated circuits packages (IC). Digital instruments are more versatile, reliable, simple and direct to operate.

1.4: PROJECT LAYOUT

With the aim of designing, constructing and testing of a digital caliper, putting the general requirement materials used into consideration. The project has been arranged as given below.

Chapter one of the project gives a general introduction of the case study and the literature review. It explains the previous works done n measuring instruments and highlighted the objective, and motivation towards the project. Chapter two explains in details how the system design was realized and implemented. Chapter three contains the construction and testing of the digital caliper. Chapter four is conclusion and recommendation.

CHAPTER TWO

2.0: SYSTEM DESIGN AND ANALYSIS

2.1: COMPOSITION OF DIGITAL CALIPER

The block diagram representing a digital caliper is shown in fig. 1. Below

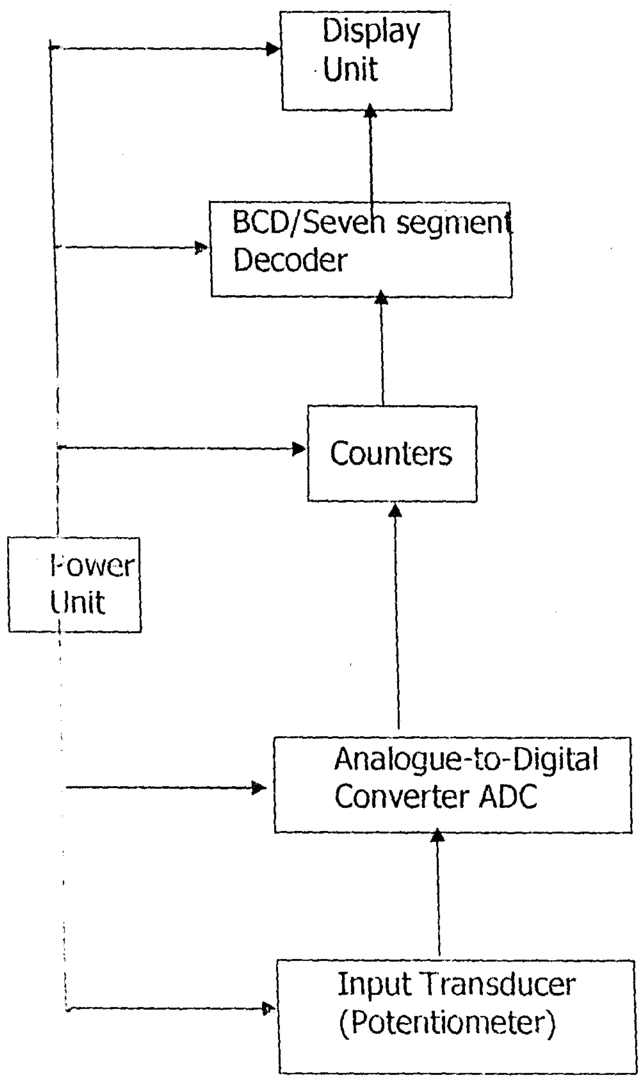


Fig. 1. Block Diagram of a Digital caliper

Each block represented above, represent a unit in the whole circuit. They are six units all together that form the caliper.

i) Power unit

ii) Input transducer (Potentiometer)

iii) Analogue to Digital Converter ADC

iv) Counters

v) BCD/seven segment decoder

vi) Display unit

2.2: THE POWER SUPPLY UNIT

The power supply source is a 9-volt D.C battery. This made it possible for the caliper to be used in anywhere, in absent of a.c source. The 9 volt is regulated to 5 volt by a voltage regulator (IC) LM7805 in order to power all the CMOS integrated circuit (IC).

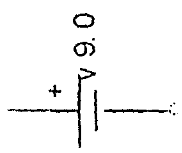
2.2.1: BATTERIES

The past few years have seen a reduction in the size and also the power requirement of electronic circuits. This has led to smaller, more portable devices and consequently to the need for small, relatively cheap independent power supplies take the form of batteries or dry cells.

Batteries are ideal for satisfying the power requirement of modern electronic circuits. On the whole, they are small, fairly cheap and can maintain a reasonably constant D.C voltage at low load currents, for an appreciable length of time. Also they need no maintenance and can be replaced by any one.

Batteries do have a number of disadvantages. For instance they have to be replaced on a fairly basis and this can be costly over a period of time. Old batteries have a tendency to leak chemical which will corrode electrical contacts and disrupt the proper operation of the device.

A battery consist of a number of cells connected in series as showing in fig



Fig

The potential difference or voltage between the two terminals of a battery is called electromotive force (e.m.f). The e.m.f is at maximum when the battery is new and decrease over time; the rate of decrease depends on the rate at which current is drawn from the battery.

The current rating of a battery is the amount of discharge current it can produce for a specified period of time with the output voltage not falling below a minim ım level.

The cells of the battery are made from a chemical called the electrolyte, which reacts with electrodes to produce energy. Therefore a battery changes chemical energy to electrical energy. The chemicals offer certain resistance of the battery and this tends to increase in value over the life of the battery. The cells making up a battery are of two main types called primary and secondary.

- PRIMARY CELLS

These ones are thrown away when they are exhausted. They are sometimes referred to as dry cells due to the fact that the electrolyte, although moist, is sealed and cannot be spilled.

- SECONDARY CELLS

These can be recharged on reversal of the chemical reaction within the cell. When the cell drives a current through a load it is discharge and this is associated with the neutralization of the ions within the electrodes. When the current is reversed the process is reversed thereby reforming the electrodes and charging the cell. The charging current must be a steady d.c current which is obtained from an external voltage source.

2.3: TRANSDUCER UNIT

Transducer is the generic name given to any device that converts energy or information from one form to another and verse visa. In electrical engineering, the interest is on energy conversion from other forms into electrical energy or vice versa.

Without suitable transducers, no measuring instrument or automatic control equipment can be effective. There are many transducers as these are physical quantities to be measured by electrical and electronics measuring instruments. They include:

(a) Force transducer (load cell).

(b) Acceleration transducer (force balance type)

(c) Fluid pressure transducer

(d) Temperature transducer

(e) Velocity transducer (Tachometer)

(f) Position transducer (Potentiometer)

In this project work, position transducer is been consider in the design of digital caliper.

2.3.1: VARIABLE Potentiometer

Variable potentiometer transducer are in wide use in measurement systems, mainly because of the ease with which they can be adapted to give an indication of linear displacement, but also because of their relatively high electrical output. Potentiometers for measurement purpose are usually made by winding a resistance wire upon a rigid former, the variable sliding contact being a pressure contact upon the wire surface. Alternatively, the resistive element may be a carbon film, deposited upon a former. The output voltage per unit deflection of the sliding contact is dependent upon the supply voltage to the potentiometer; within limits imposed by the heating of the element, the sensitivity may be increased by increasing the supply voltage.

The resolution of the potentiometer is limited by electrical noise generated in the potentiometer. Electrical noise is defined as small random voltage as generated within the system, which mask smaller voltages generated correctly by the transducer. Such noise voltages are generated in several ways.

- CONTACT NOISE. A major source of noise is the sliding contact if the potentiometer is wire wound the sliding contact will in general, contact several adjacent wound turns at the same time. If this were not so, then the slide would necessarily be narrow and pointed , and would therefore penetrate into the contact slides over the turns, it alternately short circuit several adjacent turns, causing small but definite steps to occur in the output voltage characteristic, which cannot be distinguished from similar small steps in the output voltage due to small displacement of the slider. Another source of contact noise is wear or dirt upon the track.
- THERMAL OR JOHNSON NOISE

  Is characterized by randomness of amplitudes and frequency distribution. The noise of the signal is developed because of the random motion of the current carries in the electrical conductor. Noise of this type is spoken of as white noise. Its frequency distribution being constant over the whole spectrum. Consequently, the total noise power developed is proportional to the frequency bandwidth of the signal processing system.

The root means square noise voltage generated in a resistor is given by

$E_{noise} = \sqrt{4KTR\$f}$

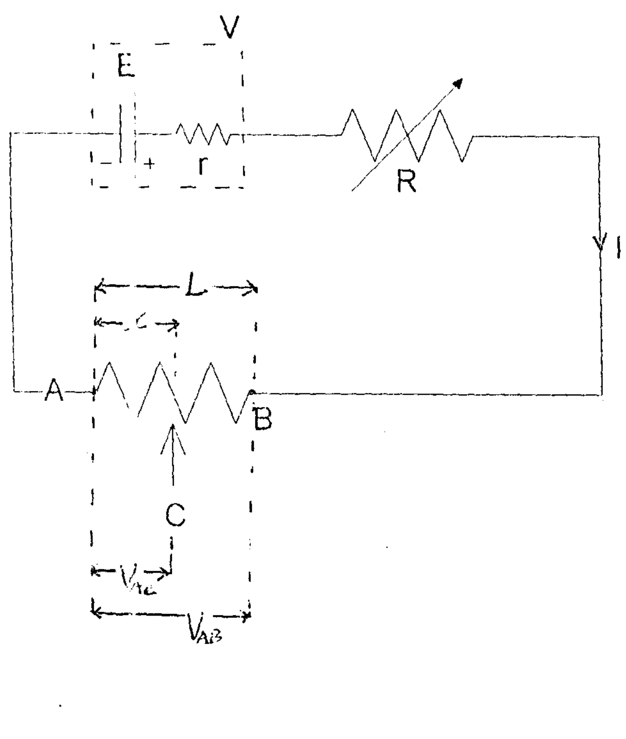
T= absolute temperature k

R = resistance value

$= frequency bandwidth of signal processing in Hz

K= Boltzman constant = 1.3*exp-23.

The function of the potentiometer as a transducer is to transform an input displacement of the slider into a proportional voltage. The basic element is usually a coiled wire or strip of conducting material.



The circuit consist of a source of e.m.f, a variable resistor and a resistance wire AB of length L. A sliding contact C may connect anywhere along L and x from A. If no current is taken through the connects and A and C, then the current I is the same through ACB.

$$A_{AB} = IR_{AB}$$

$$V_{AC} = IR_{AC}$$

$$\therefore \quad \frac{V_{AB}}{V_{AC}} = \frac{IR_{AB}}{IR_{AC}} = \frac{R_{AB}}{R_{AC}}$$

Also, if the resistance of the wire is proportional to its length, then

$$R_{AB} = \text{constant x AB}$$

$$R_{AC} = \text{constant x AC}$$

$$\therefore \quad \frac{V_{AB}}{V_{AC}} = \frac{\text{constant x AB}}{\text{constant x AC}}$$

$$\frac{V_{AB}}{V_{AC}} = \frac{AB}{AC} = \frac{L}{X}$$

$$x = \frac{V_{AC}}{V_{AB}} \times L$$

Thus, if V_{AB} is maintained at a constant value, V_{AC} may be measured and is proportion l to this distance x.

If the instrument is to sense a dimension of 0.1am, then the voltage across the length of the wire AB is determined by Resolution, which is the smallest change in the input variable to which the measuring system will response.

$$\text{Resolution of the ADC} = \frac{V_{ref}}{2^8} \frac{5V}{256} = 0.01953V$$

This means that for each 0.01953V increase in voltage at the analogue input, the binary output increase by 1 i.e. 1mm which is equal to 0.1cm.

The Instrument will sense anything above 0.1cm.

Therefore, sensitivity of the Instrument is the change in output of the Instrument as a result of change in quantity being measured

For 0.1cm

If 0.01953V ≡ 0.1cm

$$IV = \frac{0.1cm}{0.01953} = 5.12cm$$

$$5V = 5.12cm \times 5 = 25.6cm$$

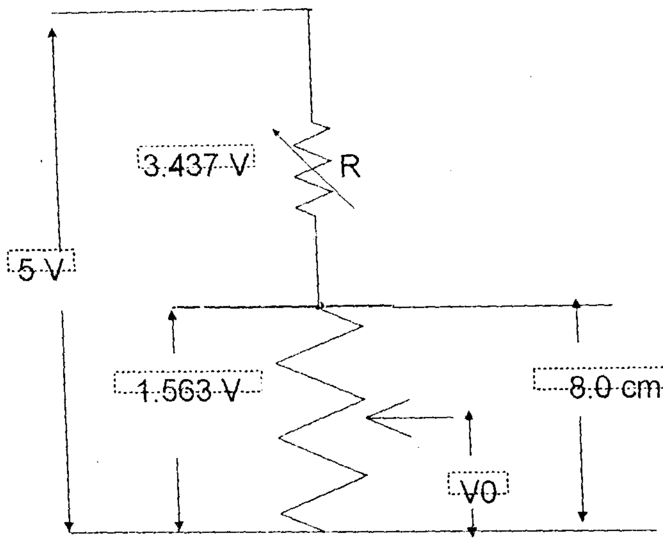
In this project work, it is require to design a caliper of length 8.0cm

Therefore, the voltage across the length (L = 8.0cm) of the wire is given by

$$IV = 5.12cm$$

$$1cm = \frac{IV}{5.12} = 0.1953v$$

$$\therefore 8.0cm = 0.1953v \times 8 = 1.563v$$



Voltage across the length L = 1.563v

Voltage across variable resistor = 5 - 1.563 = 3.437v

The resistance of the wire = 9.4km.

The value should be high enough in order to prevent the wire from heated up.

The value of the variable resistor can be calculated by voltage decoder theorem

$$V_R = \frac{R}{9400 + R} \times 5$$

$$3.437 = \frac{(R \times 5)}{94.00 + R}$$

$$3.437\,(9400 + R) = 5R$$

$$R = 20.68\text{k}\Omega$$

2.4.0: The Analog - To - Digital Conversion Unit

This is a very vital section of the Digital caliper, since as the name implies, it converts the voltage reading from the output of the potentiometer which is in analog form, into digital format.

The Analog to digital converter (ADC) used here is the ADC0804 which is a CMOS 8 bit successive approximation A/D converters that use a differential potentiometric ladder, similar to the 256R product.

The ADC has the following features.

i) Easy interface to all microprocessors, or operate "stand alone"

ii) Differential analog voltage inputs

iii) Logic input and output meet both MOS and TTL voltage level specification.

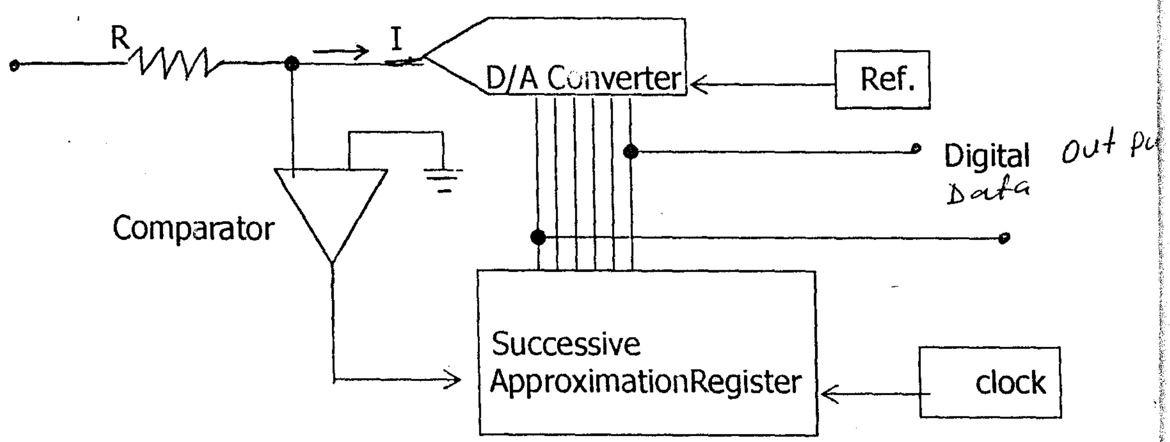
iv) Work with 2.5v voltage reference

v) 0v to 5v analog input voltage range with single 5v supply

vi) Resolution of 8 bits

vii) Conversion time of 100ps.

2.4.1: Successive - Approximation of A/D Converter



A successive - approximation register SAR controls the D/A converter by implementing the weighing logic. The operation of this converter is analogous to weighing an unknown on a laboratory balance scale using standard weights in a binary sequence such as 1, ½, ¼, 1/8, ...1/n kilogram's. The correct procedure is to begin with the largest standard weight and proceed in order down to the smallest one.

The largest weight is placed on the balance pan first, if it does not tip, the weight is left on and the next largest weight is added. If the balance does tip, the weight is removed and next one added. The same procedure is used for the next largest weight and so on, down to the smallest. After n^{th} standard weight has been tried and a decision made, the weighting is finished. The total of the standard weights remaining on the balance is the closest possible approximation to the unknown.

The SAR first turn ON the MSB of the DAC and the comparator tests this output against the analog input. A decision is made by the comparator to leave the bit ON or turn it off after which bit 2 is turned ON and a second comparison made. After n comparisons, the digital output of the SAR indicates all those bits, which remain ON and produce the desired digital code. The clock circuit controls the timing of the SAR.

2.5. 0: Counters

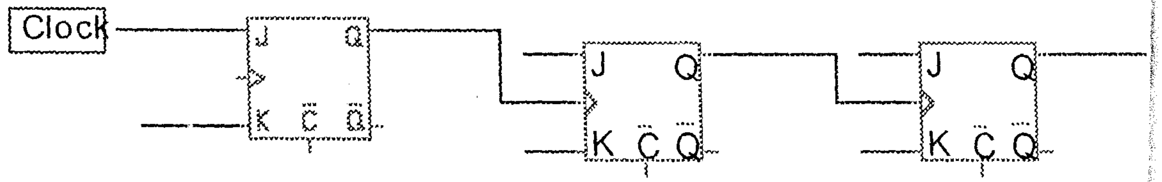
Counters are used to keep track of operations in digital computer and instrumentation system. Basically, counter is a sequential circuit that can be used to measure the number of pulses in a controlled time interval or alternatively the time interval between pulses.

2.5.1: Asynchronous Counter

These are circuits whose output does not change states at the same time with the clocking pulse. They are made up of J - K flip - flops arranged in cascade such that the output of one flip - flop serves as the input clock for the next stage.

2.5.1.1: Asynchronous Up-Counter

These are asynchronous counters, which count upward from zero. A three bit asynchronous up-counter is shown.



The clock pulses are applied only to the clock input of flip - flop A (FF(A)). This will toggle each time the clock pulses make a negative going transition (NGI). The normal output of FF (A) acts as the clock input of FF(B) so, FF(B) will also toggle each time the output of FF(A) goes from 1 to 0. Similarly FF(C) will toggle each time the output of B makes a NNT.

If the output of CBA represents a binary number with C being the most significant bit (MSB) then a binary sequence from 000 to 111 is produced. After seventh clock pulse has occurred the counter FF(A) make a NGT, which cause FF(B) to make a NGT and so on till the counter has gone through one complete cycle [(0000 through (111)] and has recycle to 000 from where it start a new counting cycle.

It is observed that FF (A) was clocked directly; FF (B) will have to wait for FF (A) to toggle before it is toggled and FF(C) will have to wait for FF (B).

Thus there is a delay between the responses of each flip-flop. For this reason, this type of counter is called an Asynchronous (Ripple) up counter.

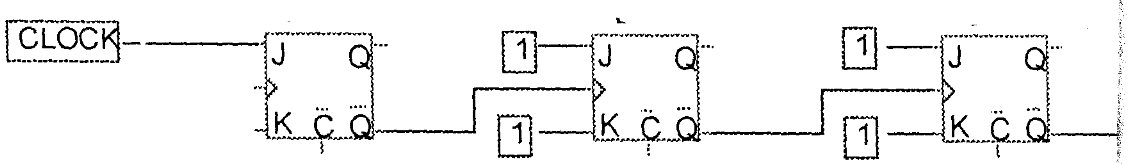
2.5.1.2: Asynchronous Down Counter

These are asynchronous counters that count downward, from a maximum count to zero.

Like up counter, the down counter flip flop toggles on the application of the clock pulses. It toggles at each NGT of the clock pulse. The inverted output of FF (A) acts as the input of FF (B). FF (B) will also toggle each time the output of A goes from 1 to 0. Similarly FF(C) will toggle each time the B output makes a NGT. If the flip-flop output CBA represents a binary number, then a binary counting sequence from 111 to 000 is produced. After the seventh clock pulse CBA equal to 000. On the eight clock pulse, FF(A) makes a NGT which causes b to make a NGT and so on till CBA = 111.

The individual change of the flip flop in asynchronous counter makes them unsuitable for driving a digital circuit like this that require instant output to drive them.

Asynchronous counter fined application in indicator lights/numerical display where these momentary states would not be noticed.



2.5.2: Synchronous Counters

A synchronous or parallel counter is one in which all the flip flop stages are triggered simultaneously. The clock pulse are applied directly to all the flip-flop and their outputs change states at the same time

2.5.2.1: Synchronous Up-Counter

A synchronous up counter counts from zero to the terminal count and recycle.

The Operation is that, the JK inputs of the flip-flops are connected so that only those flip-flop that are supposed to toggle on a given NGT will have their J = k = 1 when the NGT occurs. The counting sequence show that FF(A) has to change state at each NGT, for this reason its J and K inputs are permanently connected to J = k = 1 so that it will toggle at each NGT.

FF (B) has to change states on each NGT which occur when A = 1 this output A is connected to J and k inputs of FF (B) this ensures that FF(B) would be in toggle mode when A = 1. Also FF(C) changes state on each NGT that occurs when A = B = 1 thus A, B are connected to the J and K inputs of FF(C), this ensure that FF(C) would be in toggle mode only when A = B = 1.

2.5.2.2: Synchronous Down Counter

These counts downward from the terminal count to zero and recycle.

FF(A) has to change state at each count, for this reason J and K input are permanently connected to J = K = 1 so that it will toggle at each NGT. FF(B) has to change state at each NGT which occur when A = 0. FF(C) change state when A = A = 0.

2.6.0: Display Unit

Many modern digital device (counter) produce numerical result as their output. The numeric result appears on a visual display as a decimal numbers. An electronic calculator and a stopwatch are example of such devices. We know the actual digital circuitry within one of these devices can produce output only in binary either 1s or 0s.

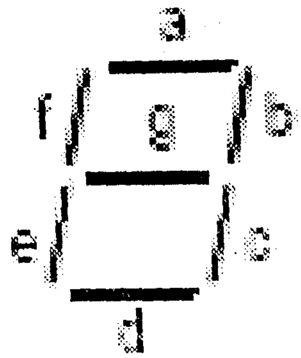
2.6.1: BCD/Seven-Segment Decoder

Digital circuits often require the decoding of binary signals to drive seven-segment displays or read out. It consist of combinational logic circuits to accept a four-bit BCD (Binary Coded Decimal) input and generate seven output signals to control the individual segments of a seven-segment display devices.

2.6.2: Seven-Segment Display

The seven-segment display gets its name from the fact that seven illuminated segments are used to configure the digits 0 - 9 (and a few lower and upper case letter). The segments are always arranged and designated as shown below.

Seven-segment LED display are fabricated in either as common-cathode or common-anode arrangement. In common-cathode arrangement, all cathodes are tied together and brought to circuit ground through a current limiting or pull-down resistor. A HIGH voltage to individual anode turns the LED segment on. In common-anode arrangement, all anodes are connected and brought to +Vcc through an external current-limiting or pull-up resistor. A LW voltage on any LED cathode turns it on.



DIGIT	SEGMENTS
0	a, b, c, d, e, f
1	b, c
2	a, b, g, e, d
3	a, b, c, d, g
4	a, c, d, f, j
5	a, c, d, f, s
6	c, d, e, f, g,
7	a, b, c
8	a, b, c, d, e, f, g
9	a, b, c, f, g

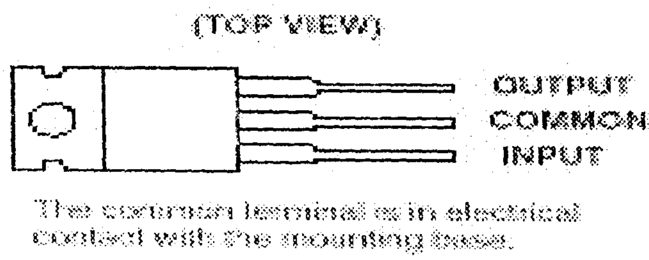
CHAPTER THREE

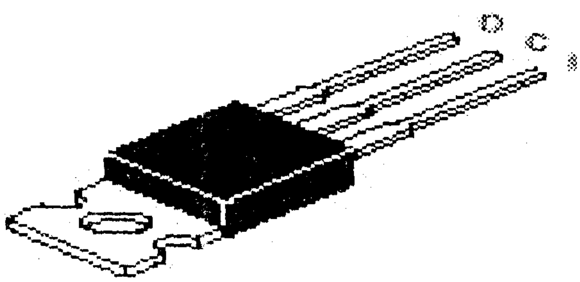
3.0: CIRCUIT DESIGN AND CONSTRUCTION

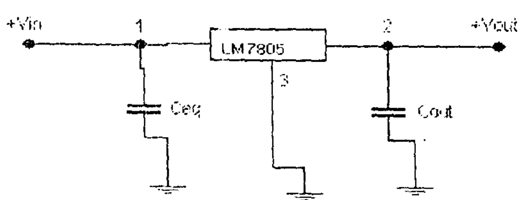
The various section of the circuit were analyzed and was constructed, as it has been designed and tested, to ensure desired results were obtained.

3.1: LM 7805

To obtain 5 volt supply from the 9 volt power source LM 7805 regulator IC is used. The IC is shown below.



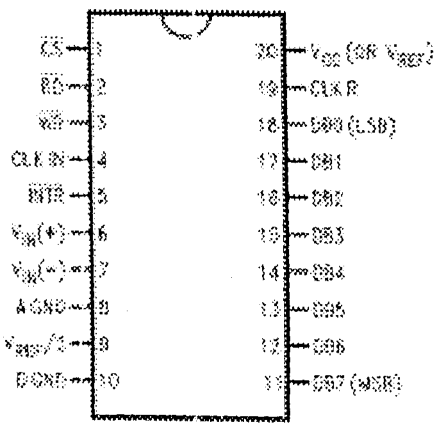




The positive lead of the unregulated D.C power supply (9V D.C) was connected to the input pin and the negative lead to the common pin. A capacitor Ceq(0.33) microfarad is usually connected between the input terminal and ground in order to cancel the Inductive effects due to long distribution leads. The output capacitor Co (47) microfarad smooth out noise and get a better 5 volt.

3.2.0: ADC0804

The ADC 0804 IC is a 20 pin Dip integrated circuit and the configuration is shown below.



Top view of the ADC 0804

The table below shows the pin description of the ADC 0804.

Pin Number	Description	Designation
1	Chip select/enable	Input pin
2	Read, to enable three state outputs	Input pin
3	Write, to start conversion	Input pin
4	Clock input (capacitor0	Input pin
5	Interrupt	Output pin
6	Differential input (positive)	Input pin
7	Differential input (negative)	Input pin
8	Analog ground	Output pin
9	Voltage reference	Input pin
10	Digital ground	Input pin
11 - 18	Data pins (bus)	Output pin
19	Clock input (resistor)	Input pin
20	Power supply	Input pin

The bar above the CS, RD, WR and INTR indicate negative logic, that is, a low on these pins indicates a true condition.

The operation of the ADC0804 is that, the circuit will "sense" an input analog voltage from the potentiometer and produce an equivalent digital output with full 8- bit resolution in a conversion time of only 100μs. Pin 4 is connected to 100pF capacitor and pin 19 to 10kΩ resistor, which generates the internal clock of the ADC.

The frequency is calculated as shown

$T \propto RC$

$T=KRC$, $F= 1/T$

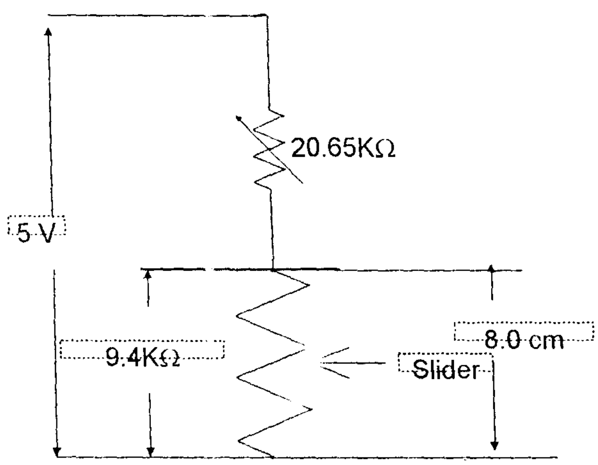
Where T=Turn ON time, K=pulse width =1.1, R and C are stated by the manufacturer of the ADC0804, R=10KΩ , C= 100pF

$$F = \frac{1}{1.1RC} = \frac{1}{(1.1 \times 10 \times 10^{3} \times 100 \times 10^{-12})} = 0.909\text{MHz}$$

This frequency was used for the whole circuitry.

3.3.0: Potentiometer

The potentiometer, which transforms an input displacement of the slider into a proportional voltage, is 9.4kΩ and 8cm long, with 20.68kΩ variable resistor as analyzed from the calculated value.



3.4.0: 40103B

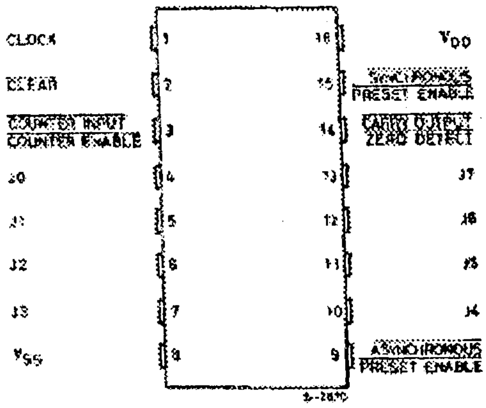
It is an 8 - bit binary counter. Consist of an 8-stage synchronous down counter with a single output which is active when the internal count is zero. It has control inputs for enabling or disabling the clock, for clearing the counter to its maximum count and for pre setting the counter either synchronously or asynchronously.

All control inputs and the CARRY-OUT/ZERO-DETECT output are active - low logic.

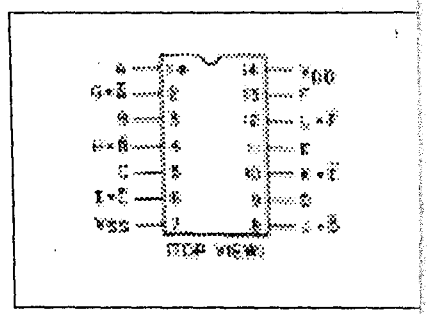
In normal operation, the counter is decrement by one count on each positive transition of the clock. Counting is inhibited when the CARRY-IN/COUNTER ENABLE (CI/CE) input is high. The CARRY-OUT/ZERO-DETECT (CO/ZO) output goes low when the count reaches zero if the CI/CE input is low, and remains low for one full clock period. When the SYNCHRONOUS PRESET ENABLE (SPE) input is low, date at the JAM inputs is clocked into the counter on the next positive clock transition regardless of the state of the CI/CE input.

The precedence relationship between control input are control by AND and NOT gate. The functional and pin diagrams of the gates are shown below.

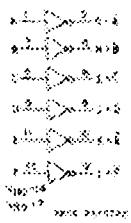
PN CONNECTION 40103B



NOT GATE PIN CONNECTION 4

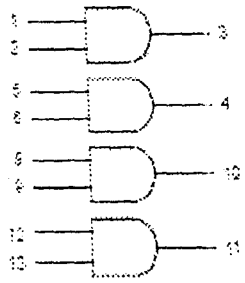


LOGIC DIAGRAM NOT GATE



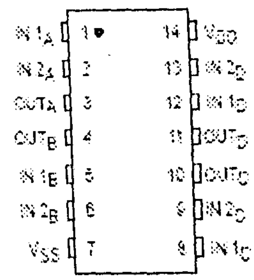
AND

MC14081B
Quad 2-Input AND Gate



AND GATE PIN CONNECTION 4081B

MC14081B
Quad 2-Input AND Gate

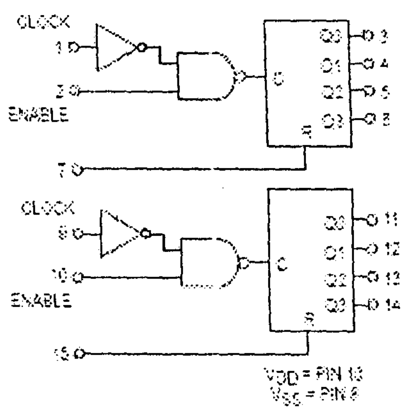


3.5.0: 4518B

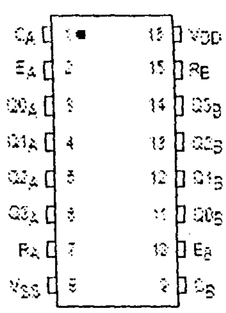
This is a dual BCD counter. Each consists of two identical independent, internally synchronous 4-stage counters. The counter stages are type D flip-flops with inter changeable clock and Enable lines for incrementing either the positive-going or negative-going transition as required when cascading multiple stages. Each counter can be cleared by applying a high level on the reset line.

The block diagram and pin connections are shown below.

BLOCK DIAGRAM



PIN CONNECTION 4518B



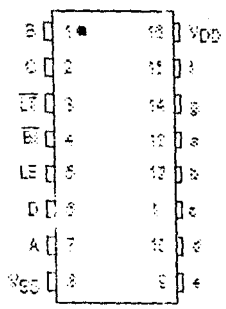
3.6.0: 4511

This is a seven-segment decoder/driver IC. It incorporates an input catch so that it can hold and display a steady digit as part of a multi-digit count, which a new count is being accumulated in the background. The catch allows the display to be up dated only at the end of each counting cycle, instead of displaying the on going count.

The main circuitry of this IC is the Decoder section. This section consists of combinational logic circuits to accept a four-bit BCD (Binary coded Decimal) input and generator seven output signals to control the individual segments of a seven-segment display devices.

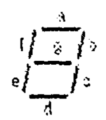
The IC pin connection is shown below.

PIN CONNECTION 4511

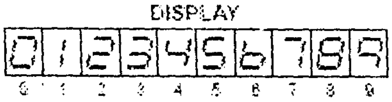


3.7.0: Seven-Segment Display

The seven-segment LED display is c common-cathode that is, all cathodes are ties together and brought to the circuit ground through 330Π resistor as a current limiting or pull-down resistor. A HIGH voltage t individual (a,b,c,d,e,f,g) anodes turns the LED segment ON.



DISPLAY



TRUTH TABLE

Inputs							Outputs							
LE	BI	LT	D	C	B	A	a	b	c	d	e	f	g	Display
X	X	0	X	X	X	X	1	1	1	1	1	1	1	8
X	0	1	X	X	X	X	0	0	0	0	0	0	0	Blank
0	1	1	0	0	0	0	1	1	1	1	1	1	0	0
0	1	1	0	0	0	1	0	1	1	0	0	0	0	1
0	1	1	0	0	1	0	1	1	0	1	1	0	1	2
0	1	1	0	0	1	1	1	1	1	1	0	0	1	3
0	1	1	0	1	0	0	0	1	1	0	0	1	1	4
0	1	1	0	1	0	1	1	0	1	1	0	1	1	5
0	1	1	0	1	1	0	0	0	1	1	1	1	1	6
0	1	1	0	1	1	1	1	1	1	0	0	0	0	7
0	1	1	1	0	0	0	1	1	1	1	1	1	1	8
0	1	1	1	0	0	1	1	1	1	0	0	1	1	9
0	1	1	1	0	1	0	0	0	0	0	0	0	0	Blank
0	1	1	1	0	1	1	0	0	0	0	0	0	0	Blank
0	1	1	1	1	0	0	0	0	0	0	0	0	0	Blank
0	1	1	1	1	0	1	0	0	0	0	0	0	0	Blank
0	1	1	1	1	1	0	0	0	0	0	0	0	0	Blank
0	1	1	1	1	1	1	0	0	0	0	0	0	0	Blank
1	1	1	X	X	X	X	*							*

X = Don't Care

* Depends upon the BCD code previously applied when LE = 0

3.8.0: Construction

The components were selected as outlined in the previous chapters and the required IC was got from the market.

Constructior was then under taken by testing the design outline stage by stage. In this regard, the power unit was first considered and the rest of the unit constructed as analyzed in the diagrams above.

These units were connected stage by stage on the breadboard and then tested. And when the required output was finally obtained, after series of checking and cross checking to ensure correct connection of all components, it was transferred to the Vero board and soldered.

Care was taken to ensure that the circuit connections were appropriate before soldering, but then it was still observed that working circuit on the bread bard will suddenly fail to work on being transferred and soldered to the Vero board. The problems were traced to the conductor lines of the vero board which could be shorted as a result of soldering. Care was taken to locate the source of the fault or the shorted conductor lines, which were immediately rectified and the circuit become functional.

An IC socket was used for all the IC to prevent frying during soldering.

3.9.0 DISCUSSION OF RESULT

The value (expected value or readings) of the project were compared with the actual reading of a standard meter rule, after the circuit has been tested and it was confirmed that it falls with the expected or an acceptable reading of accuracy limit.

The result gotten from various measurements carried out represents the appropriate value of the real displacement measured and are shown below.

No of Readings	1st	2nd	3rd
Standard meter	1.5	1.5	3.5
Project Reading	1.4	1.5	3.5

The first and second readings were carried out seventh time and the average reading is 1.488.

Accuracy which is define as the nearness to the true value of the measuring Instrument is calculated as

Error = True value – Instrument reading

$= 1.5 - 1.488 = 0.012$

Therefore, accuracy of the Instrument fall between ±0.01

CHAPTER FOUR

4.0: CONCLUSION AND RECMMENDATION

4.1: CONCLUSION

The design, construction and testing of a digital caliper was presented in this project using the techniques of analogue to digital conversion with successive approximation method. The general designed in divided into stages, whereby each module designed is handle separately, tested and confirmed fit before all the modules were then joined together finally.

The aim of the project was achieved after much technical difficulty were well handle and circuit connection precaution were observed.

4.2: RECOMMENDATION

I will like to recommend that small manufactures do venture in the mass production of this system. It is cheap to build and its efficiency is guaranteed. It will equally enable students of Electronic Engineering to appreciate the modern technology in digital systems.

Lastly to further improve the system, I recommend a 16-bit Analogue to digital converter in order to improve the sensitivity of the system.

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