DESIGN AND CONSTRUCTION OF A DUAL MODE DIGITAL COUNTER

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MINNA, NIGER - STATE.

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FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA. NIGER STATE.

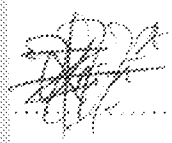
NOVEMBER 2004.

DECLARATION

hereby declare that this project is the result of my handwork and research.

ngr. Abraham Usman in the department of Electrical and Computer Engineering of

leral University, Minna, Niger State supervised the project.



9th December, 2004

LOWONISI, V. OLUWASEYI DATE

(STUDENT)

CERTIFICATION

This is to certify that this project titled **Design and Construction of Dual Mode digital counter** was carried out by **Olowonisi, Victor Olowaseyi** (99/9356EE) under the supervision of **MR. Abraham Usman** and submitted to Electrical and Computer Engineering Department, FUT Minna, in partial fulfillment of Bachelor of Engineering (B.ENGR.) degree in Electrical and Computer Engineering.

..... 09/12/24

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..... 9/12/2024

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(HEAD OF DEPARTMENT)

....

(EXTERNAL EXAMINER) — DATE

DEDICATION

This project is dedicated to almighty God for His love, mercies and protection throughout my life.

Also, to my wonderful mother, late Mrs. Odunola Mary Olowonike for her motherly love during her short sojourn through this earth.

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First and foremost, I give thanks to the Almighty God for His divine favors and mercies
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TABLE OF CONTENTS

TITLE PAGE……i
DECLARATION……iii
CERTIFICATION……iv
DEDICATION……v
ACKNOWLEGEMENT……vi
TABLE OF CONTENTS……vii
ABSTRACT……ix

CHAPTER ONE
INTRODUCTION……1
1.1 LITERATURE REVIEW……2
1.2 PRINCIPLE OF OPERATION……5
1.3 MOTIVATION……9
1.4 OBJECTIVE……9
1.5 PROJECT LAYOUT……10

CHAPTER TWO
INTRODUCTION……11
2.1 POWER SUPPLY UNIT……11
2.2 AUTOMATIC PULSE GENERATOR……12
2.3 MANUAL PULSE GENERATOR……16
2.4 MODE SELECTOR……18
2.5 CONTROL SECTION……19
2.6 DECADE COUNTER……22
2.7 BCD DRIVER/DECODER……26
2.8 SEVEN SEGMENT DISPLAY……27
2.9 MAXIMUM COUNT SELECTOR……29
2.10 CONVEYOR BELT CONTROL……30

HAPTER THREE
CONSTRUCTION.....32
1 COMPONENT LAYOUT.....32
2 HARDWARE CONSTRUCTION.....33
3 SOLDERING.....33
4 TESTING AND ANALYSIS.....33
5 TOOLS USED IN CONSTRUCTION.....34

HAPTER FOUR
CONCLUSION.....36
1 RECOMMENDATION.....36
2 PRECAUTION.....37
3 RESULT.....37

FERENCES

ABSTRACT

This project reports the design and construction of a dual mode digital counter. The counter converts the square wave pulse signal applied to its input to the binary coded decimal (BCD) and which is in turn converted to digital decimal displays. These square wave pulses are generated manually by the press of a pushbutton and automatically by the breaking of an infrared beam. The pulses generated are applied to a cascade of decade counter and BCD to 7-segment display driver. The number of pulses generated are counted, converted and then displayed in decimal form on a seven segment display, three in number, to form a three digit decimal display

CHAPTER ONE

INTRODUCTION

The design and construction of the dual mode digital counter aims at using the reliability and efficiency of the digital counter technology, which is being improved on by electronic engineers. The project aims to use this technology and improve on its versatility and adaptability.

Digital counter is an instrument, which in its simplest form provides a numerical decimal display/output that corresponds to the number of pulses applied to the input.

Technically, digital counter is a device, which connects flip-flops together to perform counting operations. The number of flip-flops connected and the manner in which they are connected determines the number of states called the modulus (MOD). The modulus also specifies the sequence of states that the counter goes through during each complete cycle.

Counters are categorized into two types according to the manner the clock pulses are applied to their inputs. They are categorized into synchronous and asynchronous counters.

The asynchronous counter, often called the ripple counter, has the external clock pulse applied to the first flip-flop and successive flip-flops are clocked by the output of the preceding flip-flop.

Flip-flops could be combined to make both asynchronous (ripple) and synchronous counters. In practice, using discrete flip-flops is to be avoided. Instead, the use of a

prefabricated counter integrated circuit (I.C.) is advised. They come in either synchronous or asynchronous (ripple) form and are usually designed to count in binary or binary coded decimal (BCD). The term asynchronous refers to events that do not have a fixed time relationship with each other and generally do not occur at the same time Therefore asynchronous counter is one which the flip-flop in the counter IC does not change state at exactly the same time because they do not have common pulse.

In synchronous counters, the clock pulse is applied to all the flip-flops at the same time, in a manner they are clocked simultaneously. The term synchronous refers to events that have a fixed time relationship with one another. A synchronous counter contains a cascade of flip-flops that are applied same clock pulse at the same time and hence the synchronous counter does not accumulate nearly as many propagation delays as is the case with the asynchronous counter.

The asynchronous type of counter is used in this project. It operates in binary number system, since binary is easily implemented with electronic circuitry and also it allows any integer (whole number) to be represented as a series of binary digit's or bits where each bit is either a zero (0) or one (1) (low or high)

1.1 LITERATURE REVIEW

The awareness of number ultimately became sufficiently extended and vivid so that a need was felt to express the property in some way, presumably at first in sign language only.

The fingers on a hand can be readily used to indicate a set of two, three, four or five objects, the numbers one generally not being recognized at first as true number.

By the use of fingers of both hands collection containing up to ten elements could be represented by combining fingers and toes, one could count as high as twenty. When the human digits were inadequate, heaps of stones were used to represent a correspondence with the elements of another set. Where non literate people used such a scheme or representation, they often piled the stones in groups of five for they had become familiar with quintuples through observation of the human hand and foot. As Aristotle had noted long ago, the undesired use today of the decimal system is but a result of anatomical accident that most of us are born with ten fingers and ten toes.

Groups of stones are ephemeral for presentation of information, hence, prehistoric man sometimes made a number record by cutting notches in a stick or a piece of bone.

However, there are limitations in these tedious and manual ways of counting. As a result of short memory of man, this various activities of man led to the development of machines used in counting and storing. (A history of mathematics (2nd edition) by Carl B. Boyer & UTAC,MERZBACH.)

1.1.1 COUNTING MACHINES

Many fields of industry and commerce have to use counting devices of one sort or the other. The most familiar type is probably the distance recorder (odometer) of cars, which is a simple type of mechanical counter. The same device is used in the hand held tally used, for example, to record the number of people passing a given point such as a station exit. Counters in times prior to now, took many forms which includes geared machines used in tape recorder counter and odometer, relays used in old pinball machines and telephone switching systems, vacuum tube used in old test equipments.

1.1.2 MECHANICAL COUNTERS

These work on the mechanism of a claw operating on a ratchet wheel with ten teeth. ach back and forth movement of the claw pulls the wheel round one tooth. A wide ring vith numerals round its rim is attached to the wheel and there is usually a casing with a vindow of the claw therefore bringing the next numeral into view. There are usually everal of these wheels side by side each operated by the one on its right so that it moves a one number for every complete turn of the first. This automatically produces counting f tens, hundreds and so on.

1.1.3 ELECTRONIC COUNTERS

Mechanical counters have the disadvantages of slow operation. They take a fraction of a econd to change number- that makes them unsuitable for high speed counting rates. In ich cases, it is common to use electronic counters of one kind or the other. (The lustrated Science and Invention Encyclopedia. Volume 5, International Edition, 1997, . 367).

Electronic counters can be defined as instruments, which automatically count and dicate the total of a succession of electric pulses or of other repetitive phenomenon that n be converted into pulses. These electronic circuits have no mechanical inertia; so ectronic counters attain far higher speeds than the fastest electromechanical counter metimes up to several million events per second. Consequently, these are useful in easuring radio wave frequency in laboratories or in counting pulses for electronic

computer read out devices. (New Age Encyclopedia, Lexicon Publication, Volume 5, 1982, Pg 283.).

Digital counters may be categorized into two types, which is the Moore machines or the Mealy machine. The simpler one is the Moore machine, which has a single count; input could be called the clock input or pulse input. The Mealy machine has additional inputs that alter the count sequence. Counting operations are mostly implemented in binary form using number sequence or system since these are easily implemented with electronics.

Binary allows any integer to be represented as a series of binary digits or bits where each bit is either a zero (0) or one (1) and after being worked on by the necessary components like the ICs which are of different functions and various transistor and diodes it displays out the appropriate decimal as its output. (Watson, John, *Mastering electronics*, Palgrave master series, 4th edition, 1996, pp184)

1.2 PRINCIPLE OF OPERATION

The dual mode digital counter consists of a cascade of combinational devices circuit. The pulses are generated in two modes, hence the name dual mode. The first mode is the automatic mode making use of an analogue circuit arrangement to achieve its goal. It consists of an arrangement of infrared source with the emission of infrared beam and a sensor. When objects break the beam, passing in front of the sensor (detector), there is a corresponding change in resistance as well as the voltage across the sensor. This is applied to the input of a comparator that compares it with a reference voltage. In this

way, in light and in dark, the detector has varying resistance as well as voltage and makes the comparator generate series of low and high pulses.

Similarly, the second mode is the manual mode. This makes use of an Schmitt trigger inverter acting as a switch debouncer to generate square wave pulses as the switch is opened and closed. Mechanical switches when opened and closed manually have the tendency to bounce, the occurrence of the number of bounces, though in milliseconds can lead to unwanted triggering, the Schmitt inverter gets rid of switch bounce and produces clean, no bounce, square wave pulses.

The circuitry is grouped into nine units, namely: The Automatic pulse generator, Manual pulse generator, Control section, Decade counters, BCD decoders/drivers, Seven segment displays, Maximum count selector, Conveyor belt motor control, Power supply unit. The function of each section is stated below;

1.2.1 Automatic pulse generator

This is a section of the design circuitry that generates pulses automatically by the principles of voltage generated across the photodiode in response to incident infrared rays. The voltage generated is applied to the inputs of a comparator.

1.2.2 Manual pulse generator

This section generates square wave pulses by the action of pressing of the push button.

1.2.3 Control section

The control section is responsible for the controlling of the start of count and automatic reset of circuit at power up.

1.2.4 Decade counters

The decade counter is a special type of sequential circuit with a single clock input and a number of outputs. Each time the counter is clocked, one or more of the outputs change states. The decade counters are chained to provide counting and a digital display of the count. Each stage's ninth count is used to clock the following stages to provide the carry to the tens, hundreds counters and so on, if more stages are needed.

1.2.5 BCD decade/driver

This section is concerned with the conversion of coded information such as binary number into a number coded form such as decimal form. This type of decoder accepts the BCD code at its inputs and provides outputs to energize seven segment devices to produce a decimal readout.

1.2.6 Seven-segment display

The seven-segment display uses its seven-segment configuration to form the decimal characters 0 through 9 along with a very limited number of letters by energizing certain combination of the segments.

1.2.7 Maximum count selector

This is a cascade of hardwired connections to the binary coded decimal output of the decade counter to the AND gate and onto the 3 – to – 1 switch. The selected mode stops the count when attained.

1.2.8 Conveyor belt motor control

This section starts and stops the conveyor belt motor when maximum count is attained.

1.2.9 Power supply unit

These supplies regulated +5V power for the TTL digital circuitry operation.

The block diagram of the design circuitry of the dual mode digital co unter is shown in the figure below:

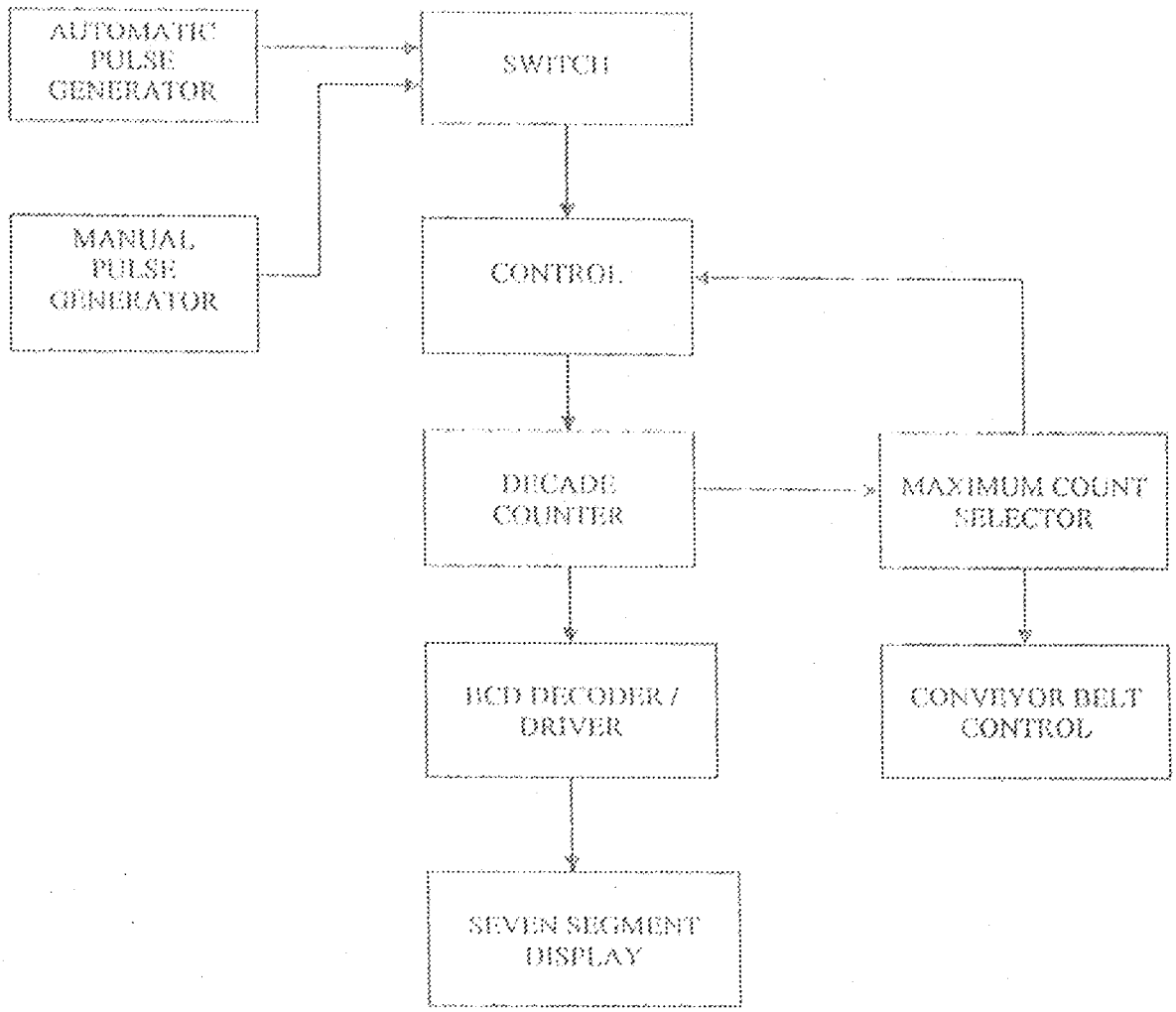


Fig.1.1 Schematic block diagram of the dual mode digital counter

1.3 MOTIVATION

Modern devices in a global term are getting more digitalized. The need for electronic digital display has increased and more devices are requiring the use of digital displays and counters. Almost all modern electronic equipments or devices are being digitally controlled and as well have digital numeric displays, which are all made up of digital counters. The displays on digital radio receivers, television sets, electronic wristwatches, telephone handsets and many other electronic devices iterates the efficiency and convenience provided by digital counters. The ease by which digital counters can be adapted and used in different applications, for different purposes and its effectiveness prompts the idea for the dual mode counter. Indisputably, most modern electronic equipments from laboratory equipments to kitchen hard wares are being controlled by digital counter technology. Modern electronic measuring instruments from hospital thermometer to digital voltmeter all use digital displays and counter. Digital counters are used in control of traffic, control system, digital clock, electronic score board and bill boards. Also in automatic parking control, parallel to serial data conversion etc. All these vast application and adaptability of the digital counter attest to the effectiveness, efficiency and widespread use and acceptance of the digital counting technology hence the motivation to adapt the digital counting technology to achieve the purpose of this project.

1.4 OBJECTIVE

1.) To design and build a simple low cost, low power device to aid the counting of object automatically on a conveyor belt.

2.) To design and construct a device to aid in manual count of either object or people in a gathering manually.

3.) To enable the preset of a maximum count limit to control the number of items counted, separating them into batches.

4.) To ease the counting of objects on the conveyor belt by the use of infrared beam.

1.5 PROJECT LAYOUT

Chapter one introduces the project and review related development and bri ef history related to digital counting and the dual mode digital counter.

Chapter two begins with theories related to the design of the system, the d esign, its analysis and calculations.

Chapter three reports the construction and testing of the entire work.

Chapter Four discusses results obtained, provides recommendation as regi rds the work. The final conclusions based on findings in the course of the work are incl ded here.

CHAPTER TWO

DESIGN ANALYSIS AND CALCULATIONS

INTRODUCTION

In order to design and analyze the entire project circuitry properly, it was broken down into nine broad sub-systems. Each of these sub-systems is further sub divided into parts (modules) to ease design and enhances explaining and understanding. These sub division were earlier shown in the fig.1.2 above.

2.1 POWER SUPPLY UNIT

TTL logic circuits require a standard power supply of 5V. The amount of tolerance is not very large and the limits of reliable operation are between 4.5V and 5.5V; it is therefore imperative that some form of power supply regulation be used. Power supply circuits form an interesting and quite important branch of electronics in themselves and the design of a good power supply used to be very difficult. Fortunately, we now have cheap and extremely reliable power supply regulation ICs that greatly simplify the job.

The figure below shows a supply suitable for use with a 9V battery.

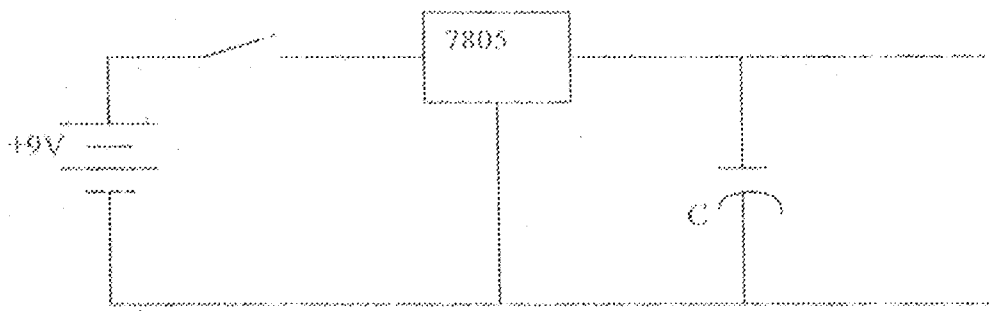


Fig. 2.1 Power supply unit

The regulator IC, type 78LS05, has a bigger brother, the 7805, which can supply up to 1A.

2.2 AUTOMATIC PULSE GENERATOR

The automatic pulse generator or tachogenerator is an analogue circuit, which makes use of a light emitting diode and a photodiode to generate high and low voltage levels. The comparator is fed with the varying voltage level signals. The photodiode offers different resistances in the presence and absence of light incident on it. This varying voltage level is compared with the reference voltage as determined by the potentiometer. The comparator outputs a high when light is not beamed on the photo-diode, that is, in the dark mode and a low when light (infra-red) is incident on it.

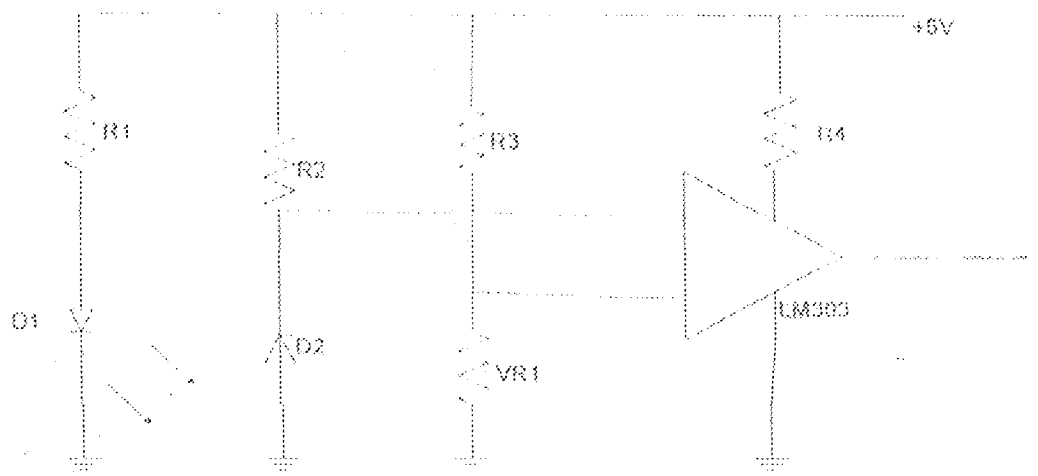


Fig. 2.2. Automatic pulse generator

Light emitting diodes (LEDs) are two lead devices that are designed to emit visible or infra-red light. When a LED's anode lead is made higher in potential difference than its cathode lead (by at least 0.6V - 2.2V), current flow through the device and light is emitted. The infrared LED is designed to emit infrared photons that have wavelengths

between 880 – 940nm. Infrared LEDs are actually more efficient in output for a given current than LEDs operating in a visible part of the spectrum; they are widely used for remote control and sensing application.

To protect the LED from excessive current, a resistor is placed in series with the LED. The value of the resistor in series R_1 depends on the forward voltage, V_F of the LED, the supply voltage V_s and the desired forward current I_F.

$R_1 = (V_s - V_F) / I_F$; $V_s = 5V$; $V_F = 1.7V$; $I_F = 100mA$, $R_1 = (5-1.7)/100m A = 33\Omega$;

$R_2 = (V_s - V_F) / I_F$; $V_s = 5V$; $V_F = 1.28V$, $I_F = 3.5\mu A$, $R_2 = (5-1.28)/3.5\mu A = 1.06M\Omega$;

The sensor or photodiode is a two lead device that converts light energy (photon energy) directly into electric current. Photodiode are used in reverse biased mode and the leakage current will then depend on the amount of light falling on the device. Photodiode are useful for measurement applications, since the leakage current is directly proportional to the light intensity over a wide range.

Silicon is generally used for photodiode, so the peak response to light is in the infrared region. The actual of current is also rather small. A typical photodiode in light have a dark current in bright sunshine of 3.5μA, quite a substantial amplification is therefore required for most application and this would usually be provided by an operational amplifier.

The photodiode when in darkness has no current flowing from the photodiode. However, when the photodiode is illuminated, a small current source pumps current from cathode through to the wire and into the anode.

This varying resistances and conductions in light and in darkness are made use of, to send varying voltage level signal to the input of the comparator.

The comparator is a device that compares two signals or voltage levels. In its simplest form it is represented as shown in the fig 2.3 . It has no additional external components.

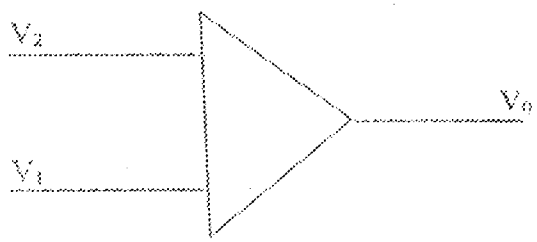


Fig 2.3 Comparator in its simplest form

If V_1 and V_2 are equal then V_o should ideally be zero. Now, if V_1 differs from V_2 by a small amount, V_o (comparative difference) is large because of amplifier's high gain. Hence, the comparator circuit can detect very small level changes, which is another way of saying it compares two signals.

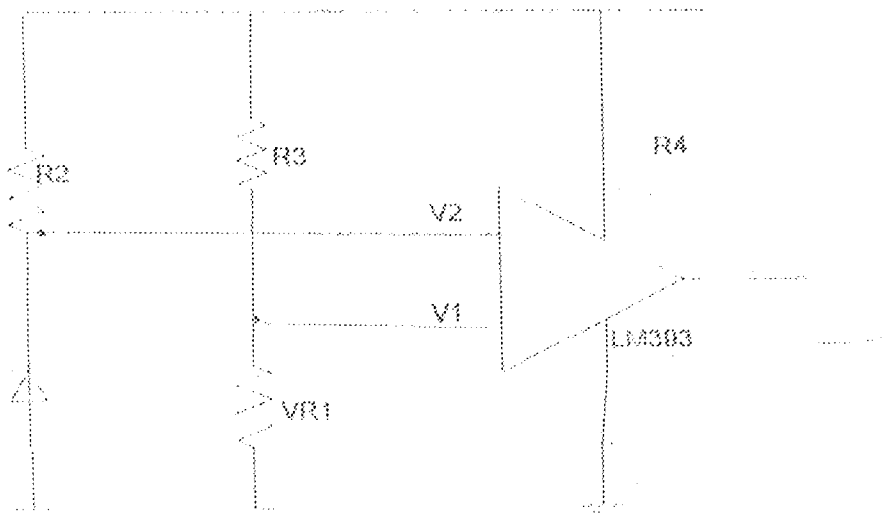


Fig 2.4 . Comparator configuration with photodiode

The variable resistor sets the reference voltage as such sets the sensitivity of the photodiode.

The comparator is connected as an inverting operational amplifier. The non-inverting terminal is grounded whereas VR_1 connects input signals V_i to the inverting input.

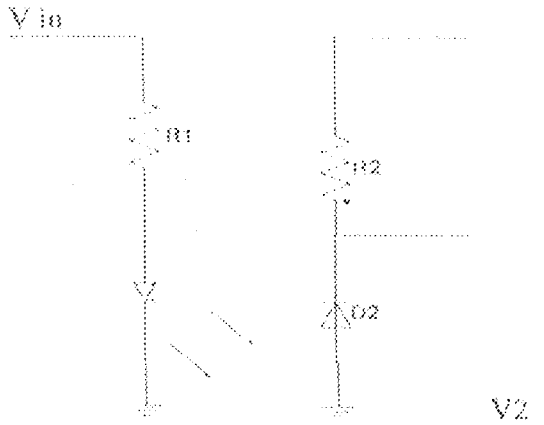


Fig.2.5 a. In light

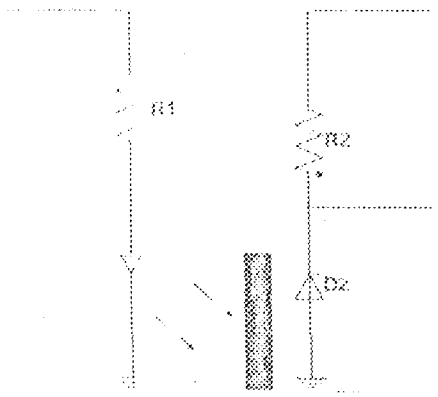


Fig.2.5 b. In Darkness

In light, voltage across photodiode is about 0.6v this is applied across the input V2 of the comparator. In darkness, voltage across photodiode is zero, therefore the total voltage supply will be applied across the input V2 of the comparator. Now, choosing reference voltage, V1 to be 1V, that is, V1 higher than V2 in light and lesser than V2 in darkness.

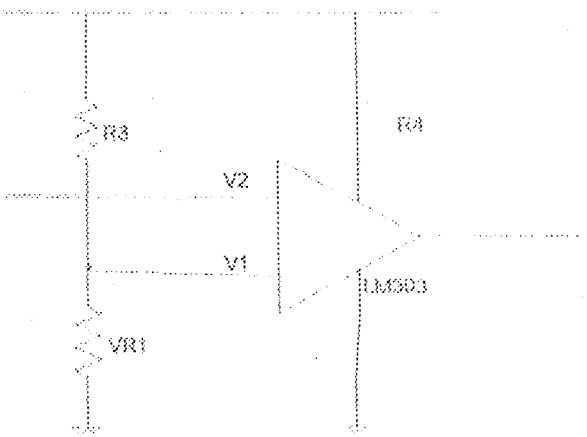


Fig.2.6 .Reference voltage, V1 of comparator

$V1 = (VR1/(R3+VR1)) \times V_{in}$, choosing R3 to be 1K, knowing that V_{in}=5V, and reference V1 chosen to be 1.5V. The variable resistor value can be set to $VR1=V1 \times R3/(Vin-V1) = 1.5 \times 1000/(5-1) = 375\Omega$, this can be varied to increase or decrease to reference voltage.

2.3 MANUAL PULSE GENERATOR

The manual pulse generator or the one shot clock generator uses a switch debouncer circuit to achieve the square wave pulse needed. The needed square wave pulse is generated with the use of the Schmitt triggered gate. These are special purpose logic gates that come with Schmitt triggered inputs. Unlike the conventional logic gates, Schmitt-triggered gates have two inputs threshold voltages. One threshold voltage is called the positive threshold voltage (V_{T+}), while the other the negative threshold voltage (V_{T-}). Examples of Schmitt-triggered ICs include the quad 7404 inverter, the quad 2-input NAND gate and the dual 4-input NAND gate. Also, the 7414 used in this project.

As said above, the 7414 Schmitt trigger inverter has two-threshold voltage (V_{T+}) and (V_{T-}). To make the output go from low to high, the input voltage must dip below V_{T-} (which is +0.9V for this particular IC); to make the output go from high to low, the input voltage must pop above V_{T+} (which is +1.7 for this particular IC). The difference in voltage between V_{T+} and V_{T-} is called hysterisis voltage. The symbol used to designate an Schmitt trigger is based on the appearance of its transfer function as shown below.

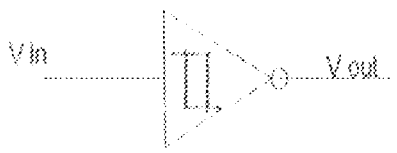


fig.2.7 Schmitt trigger

When a mechanical switch is opened or closed, the metal contacts tends to bounce a number of times before coming to rest due to inherent spring –like characteristics of the contacts. Though the bouncing typically lasts no more than 50mS, the results can lead to false triggering as shown in the diagram below.

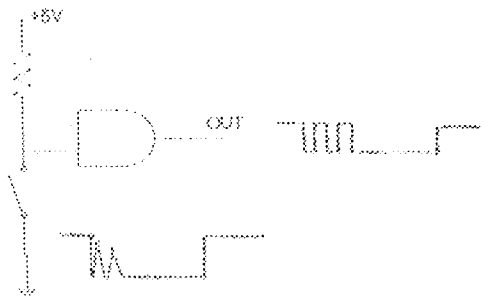
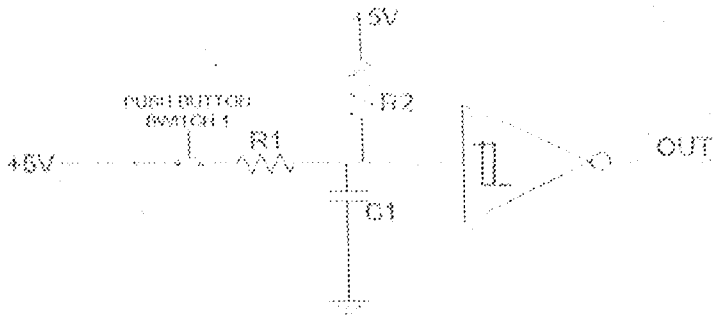


Fig 2.8 Example Of Switch Bounce

The simple way of getting rid of switch bounce is to use the switch debouncer circuit. There are different types of switch debouncers, the cross NAND SR- latch type switch debouncer, the D – type flip-flop switch debouncer etc.

Used in this project is the Schmitt –triggered inverter along with a unique RC timing network shown in fig 2.9 below.



Switch	Out
Open	Low
Close	High

Fig. 2.9 Switch Debouncer using Schmitt triggering inverter

As shown in the truth table, when switch is at A, the output is low and at position B, outputs is high and smooth (bounce free). The RC network forms the timing; the charge - up time constant ($R_2C \approx 10K\Omega \times 0.1\mu F$) ensures sufficient leeway. When the switch is

open, the capacitor is fully charged (+5V) and the output is low. When the switch is closed the capacitor discharges rapidly to ground through the 100-Ω resistor, causing the output to go high. Now, as the switch bounces, the capacitor will repeatedly attempt to charge slowly back to +5V via the 10KΩ resistor and then again will discharge rapidly to zero through the 100-Ω resistor, making the output high. By making the 10Ω pull-up resistor larger than the 100Ω discharge resistor, the voltage across the capacitor or the voltage applied to the inverter's input will not get a chance to exceed the positive threshold voltage (V_{T+}) of the inverter during the bounce. Output remains high regardless of bouncing switch.

2.4 MODE SELECTOR (DOUBLE POLE DOUBLE THROW SWITCH)

The switch used is the pole double throw switch. This is used so that when selecting either the automatic mode or manual mode, the sections are powered on selection and its outputs is equally connected to the input of the decade counter via the three input AND gate (control section). This ensures that only the section being used is powered when in use while the other unused section is not powered.

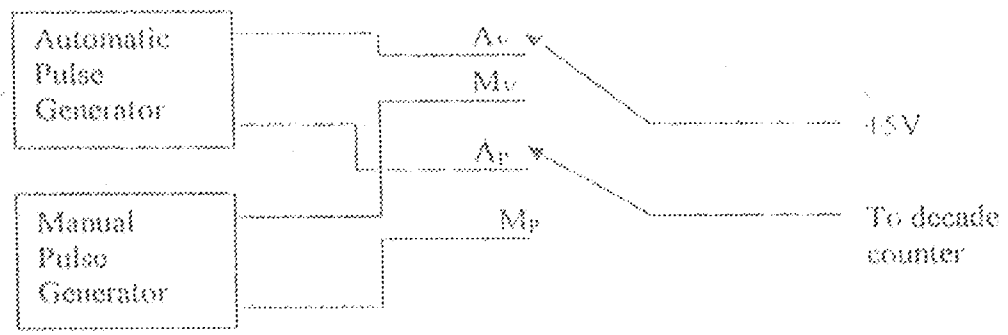


Fig 2.10. Two-way mode selector

A_V – Automatic section voltage supply

A_P - Automatic section pulse output

M_V - Manual section voltage supply

M_P - Manual section pulse output

2.5 CONTROL

The control section of the project circuit is responsible for the start of the count and for the automatic reset of the circuit at power-up. It acts as a 3-to-1 switch controlling the clock pulse input to the decade counter.

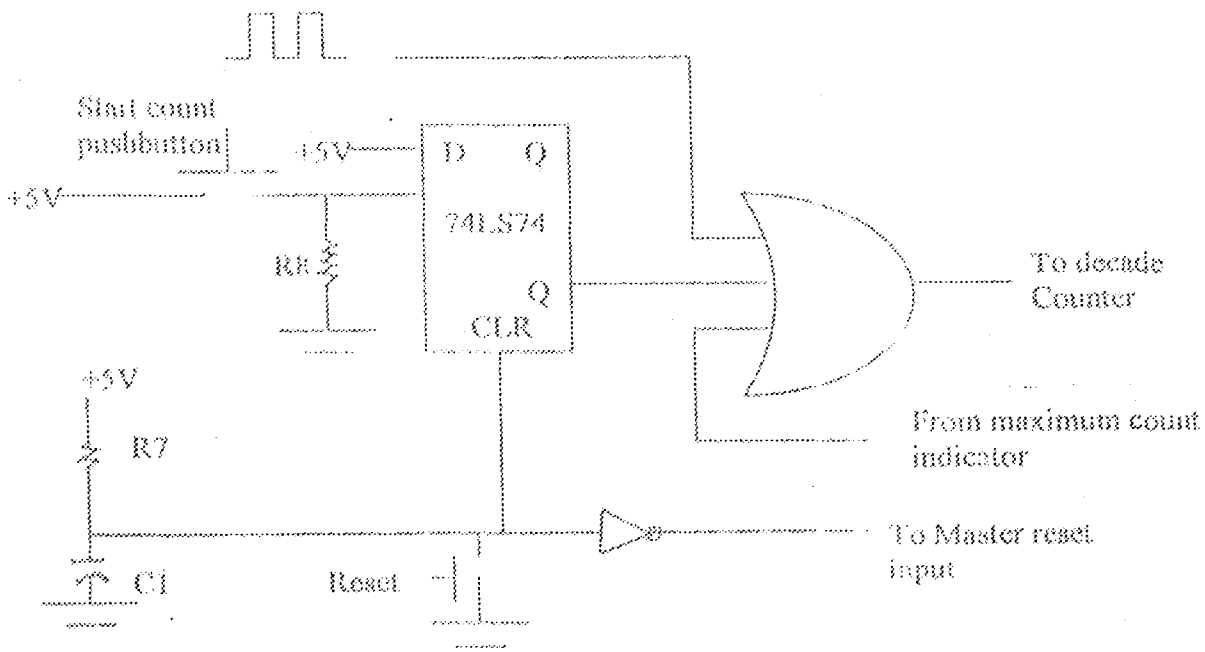
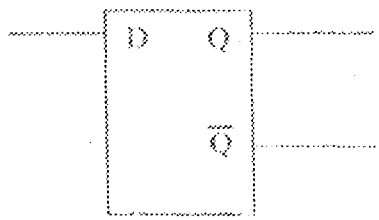


Fig 2. 11. Control Section

The D-type flip-flop (data flip-flop) is a single input device. It is basically an SR flip-flop where S is replaced with D and R replaced with inverted D- the inverted input is tapped from the D input through an inverter to the R input as shown below. The inverter

ensures that the indeterminate condition (race or not used states S = 1, R = 1) never occurs. At the same time, the inverter eliminates the hold condition so that there is left with only set (D=1) and reset (D = 0) condition. The circuit below represented a level triggered D-type flip-flop.

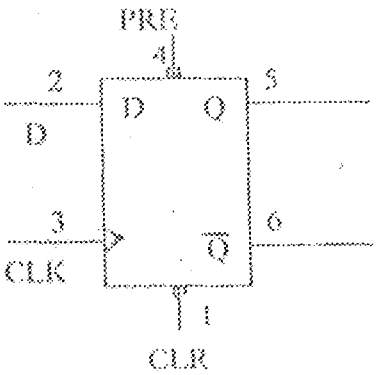


D	Q	$\overline{Q}$	MODE
0	0	1	Reset
1	1	0	Set

Fig.2.12 D-type flip-flop Logic symbol

To create a clocked D-type level triggered flip-flop, first start with the clocked level-triggered SR flip-flop and add an inverter.

The popular edge triggered D-type flip-flop IC, the 7474 (e.g. 74HC, 74LS74). It contains two D-type positive edge triggered flip-flop with asynchronous preset and clear inputs.



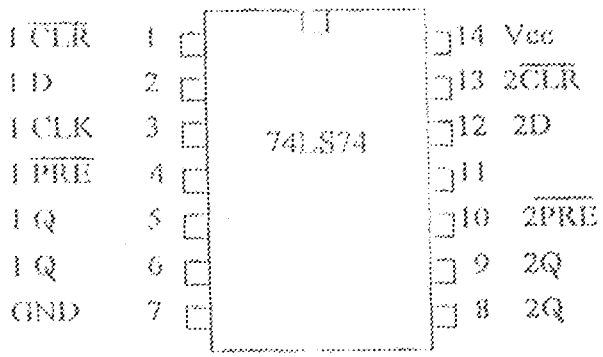


Fig.2.13. D - type Flip flop

Fig.2.14. 74LS74 IC package

Before the count begins, the D flip-flop is $\overline{Q}$ (inverted Q) output is hold high, disabling

the clock from reading the first counter's clock input. When the push-button switch is closed, the flip-flop's inverted Q output goes low, enabling the first counter to count. The three input OR gate is enabled if any or all its three input lines are high. To activate the decade counter, the clock input pin, CLK_0 (internally negated) must be low. This line can only be low if the three input lines are low. The three inputs are from the pulse generator; the start count flip-flop; and the maximum count line. Since maximum count has not yet been reached, the line is at zero; also the start count button is kept high until the start button pushbutton is pressed to keep clock disabled. With this arrangement, the output of the 3-input OR gate is kept high. At the press of the start button, its line goes low, now the maximum count line is low likewise the start count line. The pulse wave goes high and low at different intervals so at low pulse (all inputs low), output is low and this activates the decade counter to count, at high pulse (2 inputs low, 1 input high) output of 3 inputs OR gate goes high and this deactivates the decade counter. When maximum count is reached, its line goes high, 3-input OR gate's output goes high and count is stopped. The control section is also responsible for the manual and automatic power-up clear (reset) of the circuit.

In sequential circuits, it is usually a good idea to clear (reset) devices when power is applied. This ensures that devices such as flip-flops and other sequential ICs do not start out in a weird way (e.g. Counter IC does not start counting at say 1101 instead of 0000). A simple technique used to provide automatic power-up clearing is by the use of an RC network to implement the function of clearing (resetting).

When power is off (switch open), the capacitor, C2 is uncharged (0V). Once the power is turned on (switch closed), the capacitor begins charging up towards V_{cc} (+5V). However,

until the capacitor's voltage reached 2.0V, the CLR line is considered low to the active-low clear input. After a duration of t =RC, the capacitor's voltage will have reached 63% of V_{CC} or 3.15V after a duration of t = 5RC, its voltage will be nearly equal to +5V. Since the flip-flop IC requires 2.0V to be placed back into synchronous operations, you know that t = RC is long enough. Thus, by rough estimate, if the CLR line is to remain low for 1μS after power up, then RC must be set to 1μS.

t = RC = 1μS Setting R = 1 KΩ

C = t / R = 1μS / 1KΩ = 0.001 μF

Therefore making, R = 1KΩ and C = 0.001μF achieves this aim.

This automatic resetting scheme can be used within circuits that contain a number of resettable ICs. If an IC requires an active high reset as in the project circuit, then an inverter is throw in and create an active high clear line as shown in fig 2.22

2.6 Decade Counter

The counting function is a very important one in digital system. There are many types of digital counters varying in models but their basic purpose is to convert events represented by changing levels or pulses to generate a particular code sequence. In order for a counter to perform its function properly it must have the ability to remember the present number so that it can move on to the next proper number in sequence. Therefore storage capability is an important characteristic of all counters and flip – flops are normally used to implement them

A counter is a special type of sequential circuit with a single clock input and a number of outputs. Each time the counter is clocked, one or more of the outputs change state. The

output from a sequence with N unique values. After, the M value has been observed at the counter's output terminals, the next clock pulse causes the counter to assume the same output as it had at the start of the sequence. A counter comprised of flip-flops can generate an ordinary sequence with a length of no greater than 2^m cycles before the sequence begins to repeat itself. The counter used for this design is referred to as a decade counter, which can be constructed from four flip-flops and a gate.

Counters can be divided into two categories, namely synchronous and asynchronous (ripple) counter. The synchronous counter clocks all the flip-flops simultaneously, whereas in ripple counter each stage is clocked by the output of the previous stage.

ASYNCRONOUS (RIPPLE) COUNTER

For a four state BCD counter consisting of four flip-flops, the output of the last propagation delays a negative edge of the input clock.

The ratio of the input frequency to the output frequency of a counter is called the modulus. The counter required for this project is mod-10 counter and as such counts in sequence from 0000 to 1001 i.e. 0 to 9. Asynchronous decade counter flip-flop cascade is shown below:

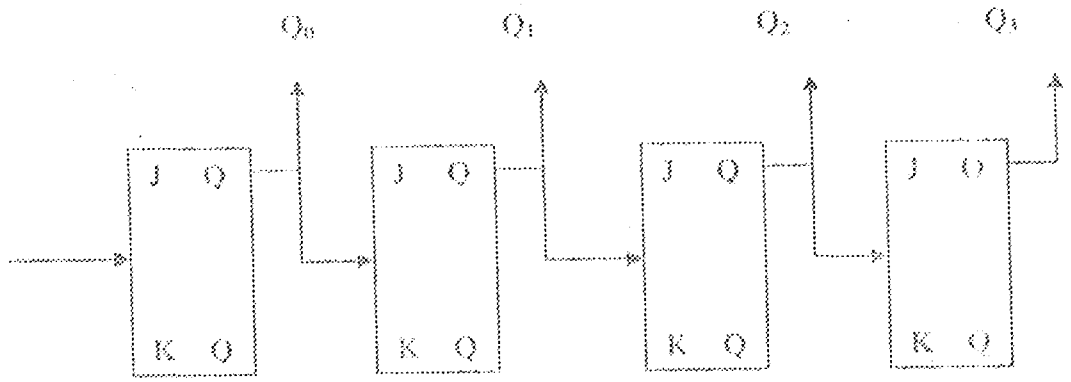


Fig.2.15 An asynchronous decade counter

The truth table and waveform for the counter above is shown below in table 2. 1.

Below the weighted binary values of the outputs Q_0, Q_1, Q_2 and Q_3, give a value equivalent to the decimal. Since the count is from 0 to 9 inclusive in this case, then the unique representation of the four bits to an equivalent decimal number can be utilized to give a visual indication of the decimal count. The use of the four bits in this way gives a binary coded decimal (BCD) count.

CLK	Q_0	Q_1	Q_2	Q_3
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0

Table.2. .1 The truth table of asynchronous decade counter

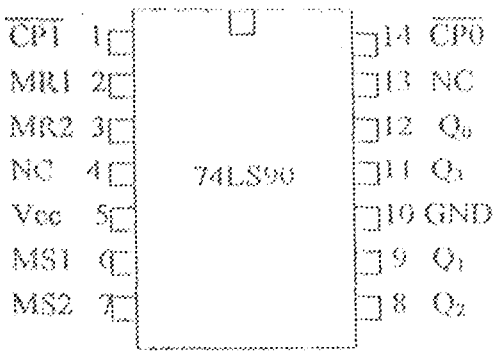


Fig.2.16 . Schematic diagram 74LS90

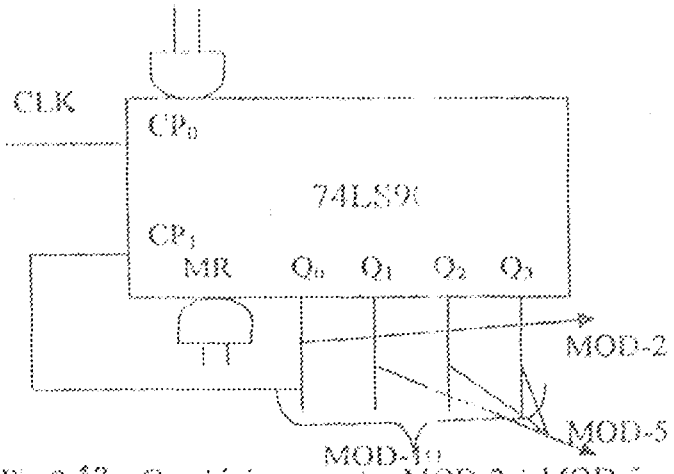


Fig.2.17 Combining counter MOD-2 + MOD-5 =MOD-10

The 7490 are 4- bit ripple counters. However, its flip-flops are internally connected to provide MOD – 2 (count to 2) and MOD- 5 (count to 5) counter sections. Again each section uses a separate clock: pin 14, CP0 for MOD- 2 and pin 1, CP1 for MOD- 5. By connecting Q0 (pin 12) to CP1(pin 1) and using CP0 (pin 14) as the single clock input, a MOD-10 counter (decade or BCD counter) can be created. The 7490 IC is a 14-pin DIP. I has input voltage of +5and is shown below in fig. 2.16 is the schematic diagram of the IC. Fig. 2.17 shows the way of connection or combining counters.

MOD-2 + MOD-5 = MOD-10 counter.

In the project circuit, three 7490 MOD-10 counters IC are cascaded together to create a three digit (decimal) counter as shown in fig.2.18

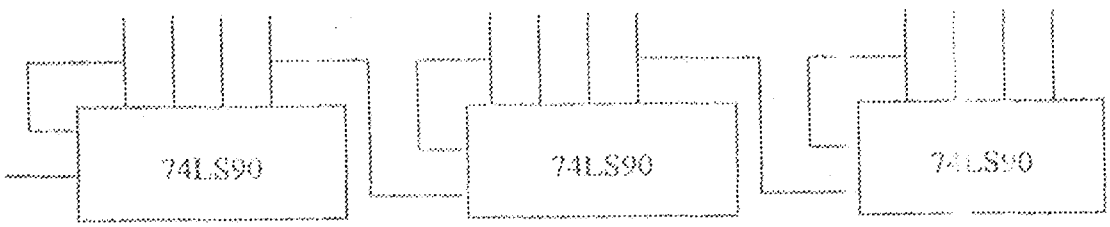


Fig.2.18 . Three decade counters cascaded to form three-digit counter

2.7 BCD DRIVER / DECODER

This converts coded information such as binary number into a number coded form such as decimal form. For example, a particular type of decoder / driver converts a 4-bit binary code into the appropriate decimal digits. The decoder / driver accept BCD code applied to its inputs and provides output to energize the 7- segment display device to produce digital decimal read out. The BCD to 7- segment decoder / driver used in this project is the 7447 IC. The IC is a 16-pin DIP type having input voltage of +5.

The 7447 is a device that more than one output can be driven low at a time. This is important because it allows the 7447 to drive a 7-segment LED display, to c reate different numbers it is necessary that it drive more than one LED segment at a time. For example, in fig.2.19 below, when the BCD number for 5 (0101) is applied to the 7447's inputs, all output except b and c goes low. This causes LED segment a, d, e, f and g to light up. The 7447 sinks current through their LED segments as indicated by the internal wiring of the display and the truth table.

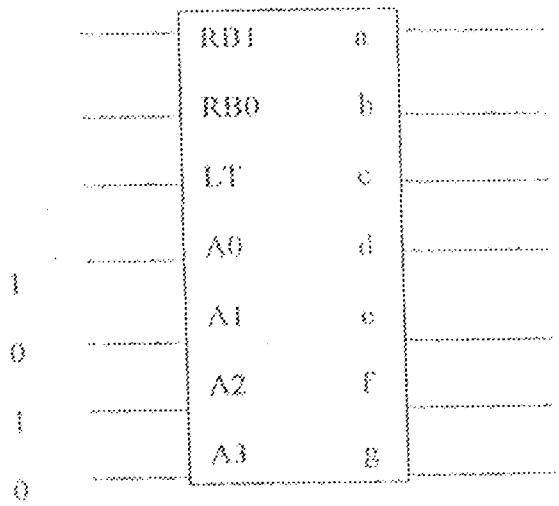


Fig.2.19 . Schematic of the 7447 BCD driver/decoder

A3	A2	A1	A0	DIGITS	A	B	C	D	E	F	G
0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	1	1	1	0	0	1	1	1	1
0	0	1	0	2	0	0	1	0	0	1	0
0	0	1	1	3	0	0	0	0	1	1	0
0	1	0	0	4	1	0	0	1	1	0	0
0	1	0	1	5	0	1	0	0	1	0	0
0	1	1	0	6	0	1	0	0	0	0	0
0	1	1	1	7	0	0	0	1	1	1	1
1	0	0	0	8	0	0	0	0	0	0	0
1	0	0	1	9	0	0	0	1	1	0	0

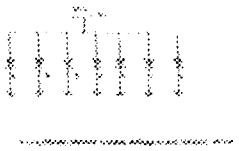
Table 2.2 Truth table for the 7447 integrated circuit.

The 7447 also come with a lamp test active low input (LT) that can be used to drive all LED segment at once to see if any of the segment are faulty. The ripple blanking input (RBI) and ripple blanking output (RBO) can be used in multistage display application to suppress a leading-edge and / or trailing edge zero in a multi-digit decimal.

2.8 SEVEN SEGMENT DISPLAY

Most digital equipment has some means for displaying information in a form that can be understood readily by the user or operator. Seven-segment displays are used in almost every electronic digital system from electronic digital clocks to electronic scoreboards. The table counting the control system has been the focus of the system application. These displays are used with logic circuit that decode a binary coded decimal (BCD) number and activate the appropriate digit of the display. A 7-segment display can be used to produce any digit 0 – 9, along with a very limited number of letters by energizing certain combination of the segment.

One common arrangement uses light-emitting diodes (LEDs) for each segment. By controlling the current through each LED, some segments will be dark so that the desired character pattern will be generated.



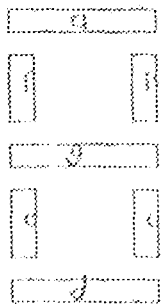


Fig.2.20. Internal wiring of seven segments display Fig.2.21. Seven segment display

Each of these segments a to g are controlled through one of the display LEDs. Seven-segment display comes in two type, common cathode and common anode type. In the common cathode type all the cathode of the diodes are tied together to ground and only +5V to be applied to the anode of these segments to light them up. This makes it possible to light any segment by forward biasing that particular LED. The common anode 7 segment display has all its anodes tied together to +5V and ground is used to light the individual segments. The common anode type is used in this project circuit. The internal wiring of the display is shown in fig.2.20 above.

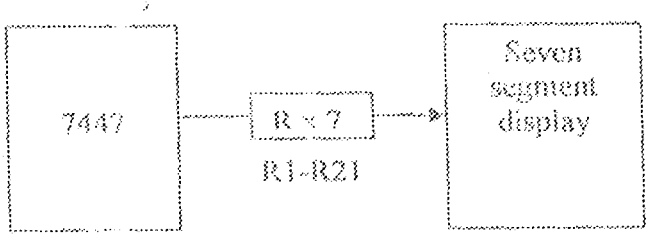


Fig.2.22. BCD driver/decoder connection to seven-segment display

The figure above shows pin output from the 74-47 IC to seven-segment decoder/driver, (the arrangement used in the project) being used to drive a seven-segment LED readout. Each segment consists of one or two LEDs, the anode of the LEDs are all tied to V_{cc} (+5V)(common anode). The cathodes of the LEDs are connected through current limiting resistors to the appropriate outputs of the decoder / driver.

The active segments for each decimal digit are shown in the table below.

Digits	Segmented selected
0	a, b, d, e, f
1	b, c
2	a, b, d, e, g
3	a, b, c, d, g
4	b, c, f, g

Digits	Segmental selected
5	a, c, d, f, g
6	a, c, d, e, f, g
7	a, b, c
8	a, b, c, d, e, f, g
9	a, b, c, d, f, g

Table.2.3 : Active segments for each decimal digit

The current limiting resistors of the segment are calculated thus:

R1 to R21 = $(V_s - V_f) / I_f$ = (5-1.7)/10mA =330Ω

2.9 MAXIMUM COUNT SELECTOR

The maximum count selector is a cascade of hard-wired connection to the binary output line of the decade counter to an AND gate. AND gates are only enabled when both inputs are high. The 12 max AND gate in this circuit has its two inputs connected (hard wired) to the output Q1 of the LSB decade counter and Q2 of middle SB which goes high at number 12. The 24 max AND gate likewise has its two inputs connected (hard wired) to

the output Q2 of the LSB decade counter and Q3 of middle SB which goes high at number 24. The AND input are wired to enable gate when IC outputs a 12 (0001 0010) at BCD outputs and a 24 (0010 0100) at BCD outputs of the center and least significant bit decade counters, this is illustrated in fig.2.23. The high is sent to the counter section i.e. the three input OR gate and subsequently disables it, stopping the clock pulse and eventually stopping the count. The maximum count can be hard wired to specified number. The enabling of the output of the AND gate also enables another AND gate, that which is involved in the conveyor belt motor control.

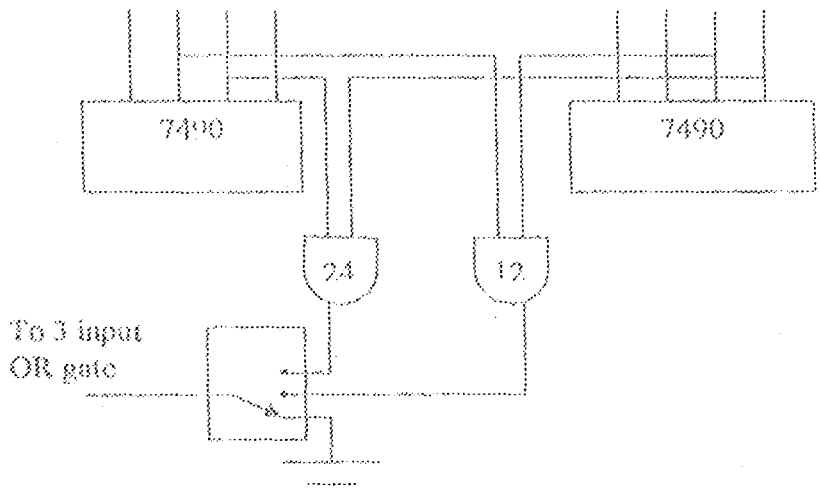


Fig.2.23. Hard wired to enable AND gates when IC outputs a 12 and a 24

2.10 CONVEYOR BELT CONTROL

The conveyor belt control works on the idea that when maximum set count is recorded by the cascade of the decade counter and the AND gate of the conveyor belt control with its two inputs high, it is enabled and subsequently activates the MOSFET. The MOSFET

here acts as a switch to turn ON and OFF the motor. When activated, it cuts the supply to the motor via the 12V relay it acts as a switch across.

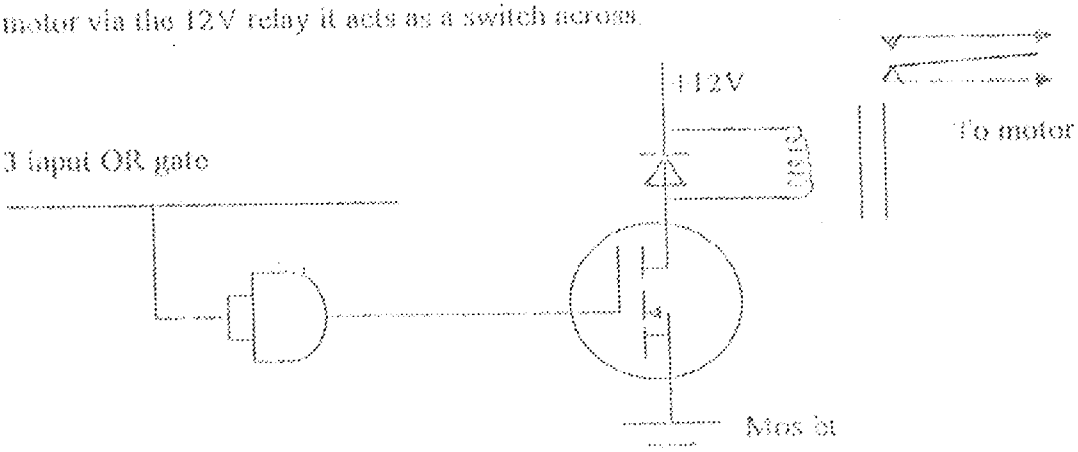


Fig. 2.2

In normal operation, at start of counter, the motor is ON and running. When the maximum count is achieved and the AND gate are controlled, the MOSFET is activated and this triggers the relay off. Thus, stopping the motor as well as objects being counted on the conveyor belt.

CHAPTER THREE

3.0 CONSTRUCTION

This chapter brings into focus, the construction procedures and techniques used to construct the device, the testing and the results obtained. The design specification of each component was followed strictly except in case of non-availability of components. In such cases, changes in design specification were done. To ease construction procedures, the project circuitry was segmented and divided into modules. Then a component layout was designed to ease the constructional problem. The construction includes a prototype on the temporary location of breadboard and then proper construction of the completed design on the Vero board. Testing was carried out at both stages and results taken and analyzed to ensure that they were within design specifications

3.1 COMPONENT LAYOUT

A layout plan for the component location on Vero board was drawn on paper. The plain paper component layout helped to ensure; Proper location for the IC's, the number of ICs the board can accommodate, the proper and best route of connection between each IC and the components, and the position of the switches and push buttons.
Proper spacing and component location were easily carried out/allocated to each component.

The segments (modules) that the circuitry was reduced to, to ease up construction includes; infra red transmitter, infra rod receiver, Pulse generator, Controls, Counter/BCD Driver & Display, Conveyor Belt/motor module, Power unit.

3.2 HARDWARE CONSTRUCTION

Preliminary construction and connection of the different components was carried out according to design on the breadboard. Each module was tested and results obtained before transferring unto the Vero board for permanently and firm soldering.

After every connection had been done and crosschecked for any open or short circuit, the circuit was again tested.

3.3 SOLDERING

Soldering was achieved with the use of a 40 W soldering iron, soldering lead and a plastic solution tube.

Some extra care taken during soldering are given below:

1) Care was taken to ensure proper contact while using little but enough soldering lead for the joints.
2) Easier and faster soldering was ensured by thinning the terminals of the components with melted soldering lead.
3) To protect active components such as IC, IC sockets were used.
4) Care was taken to ensure soldering iron temperature was not too high so as to protect the component from damage by overheating.

3.4 TESTING AND ANALYSIS

Proper care was taken to ensure neat and firm connection. Having completed the construction, a careful test and assessment of all the components connection was carried out as follows:

Step 1: The continuity and connectivity of the connecting wires and links were taken while not powered using the multimeter.

Step 2: Testing different section of the construction, from one stage to another.

Step 3: Polarities of polarized components were tested.

Step 4: Making sure that all appropriate components were properly powered taking into account positive and negative levels of supply.

Step 5: The measurement of voltage, current, resistance and capacitance were taken and compared with designed values.

After the satisfactory test as listed, the device was powered and tested in full operation. The battery provides the DC voltage of 9V input, this is reduced to a regulated 5V for powering of digital components. At initial power up, count read 000. Infrared beam is directed unto the sensor but despite cuts across it. The counter does not start counting until the start count button is pressed. Likewise, for the manual count. The maximum count button is used to select the desired maximum count this is preset (0, 12 or 24). The counter is observed to stop the count of the clock pulse as well as stop the rotation of the conveyor belt motor.

TOOLS USED IN THE DESIGN AND CONSTRUCTION

1) Computer software, (Multi Sim) was used to model the circuit; it was simulated and tested to ensure proper logic connection.
2) Initial construction was carried out on the breadboard. On transferring to the Vero board, care was taken to ensure proper soldering between junctions using jump links.

3) A 40W soldering iron and thin copper wire was used in soldering the components on the Vero board

4) Digital multimeter was used to carry out the test including continuity, voltage measurement, resistance, capacitance and current at various points on the circuit.

5) Suction tube was used to suck soldered misplaced lead from the board to avoid short circuit and ensure clean job.

CHAPTER FOUR

CONCLUSION

The aim and objective of this project work has largely been achieved, that is to design and construct a low cost, simple and functional dual mode digital counter. This has been successfully as described in the preceding chapters. This adventure into the field of digital counting/ number systems can also serve as stimulant for others who will consider undertaking topics / projects related to it. The objective and its focus are to meaningfully contribute to the economy of the country and provide convenience and accuracy of counting items on a conveyor belt, people in a given the gathering and other means of application given the adaptability of the project work. The circuit as design has few components namely; the following integrated circuits: 74LS47, 74LS90, 74LS74, 74HC14, LM393, 78LS08, infrared LED, common anode seven segment display, photodiode, pushbuttons.

4.1 RECOMMENDATION

The design can be used to count humans manually by the press of a pushbutton and count items on a conveyor belt with the facility to group them in batches of preset number selected from the maximum select switch.

In view of the strategic importance of digital electronics in our lives today, the electrical control and comfort is of equal importance. Based on this are successes and limitations recorded by the project work. The following recommendations are given:

1. Students should be encouraged to undertake research in digital electronics system in order to give them broad view into the possibilities of things that can achieved.

2. To ensured correctness and accuracy of count of people manually, the dual mode digital counter can be used in churches, assemblies, conferences, etc
3. The device in automatic mode can be used to group items in batches for loading into cartons etc, by setting and or readjusting the maximum count selector to suit desired maximum count number.

4.2 PRECAUTIONS

1. Ensured the photodiode/sensor are placed directly opposite the infrared source and within the limited distance.
2. Ensured the photodiode was well hidden in a dark enclosure with a tiny slot to receive the directed infrared beam, this is so to prevent it from responding to ambient (external) light.
3. Ensured that all components used were tested on the breadboard and corresponded to design specification with measurements by multimeter before transferring to final circuit board (Vero board).
4. Ensured that the pins of the ICs were properly connected in the appropriate way to the already soldered IC sockets.

4.3 RESULTS

From the design, analysis, construction and testing, it can be concluded that the project circuitry design performed excellent way according to design. The automatic and manual section of the dual mode digital mode constructed from the principle of photoelectric control, Schmitt triggering, digital timing and use of counter can be used to count pulses and display them numerically.

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CIRCUIT DIAGRAM OF DUAL MODE DIGITAL COUNTER