DESIGN AND CONSTRUCTION OF A CONVEYOR BELT COUNTING DEVICE

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OCTOBER, 2006

DEDICATION

I dedicate this project to God Almighty who is the beginner and finisher of every good work and also to my late father Mr. Paul Enejor whose light was dimmed that I may shine.

DECLARATION

I, Enejor Solomon Paul hereby declare that this Work Was Done By Me and to the best if my knowledge has never been presented elsewhere for the Award of a Degree. I also hereby elinquish The Copyright to Federal University of Technology Minna.

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(Signature and Date)	(Signature and Date)

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First and foremost my sincere appreciation goes to my supervisor Dr. Tsado, for his guidance during the course of this work. I express my gratitude to all my class mates and friends who have been with me through out this journey; under this category are people like Ijachi Ega, Boman Avong, Agbe Illusemiti, Zugwai Maikaje, Emmanuel Jonah, Henry Dashe and a host of others too numerous to count at the moment. To them, I say one love never dies; lets keep the bond that has held us together forever.

Special thanks also to my friends, Solomon Nuga, Prinz-Nelson, Sylvester Nwosu for their support and assistance.

Lastly, my special thanks go to my family members for their understanding and support during my stay in this school..

ABSTRACT

This project work titled "Design and Construction of Conveyor belt Counting Device" is aimed at showing the extent of electronics in control and to create a well organized and monitored production line.

It is achieved by interfacing an object counter unit with an object motion unit. The motion sensor incorporates a conveyor belt, on which the objects to be counted move upon as the belt rotates, and a light source that transmits a stream of light beam to a light sensor connected just directly opposite the light transmitter. As the moving objects cut through the light beam, the transmission of light to the sensor is obstructed; hence, this is interpreted as a count for each obstruction by the counter unit attached to the sensor.

The counter unit is divided into two: The preset counter and the normal counter. The preset counter is taken to an initial value just before setting the conveyor belt in motion while the normal counter gets incremented whenever the objects begin to cut across the light beam. This continues until normal count equals the preset value, then the counter stops counting and an alarm is triggered as the conveyor belt stops moving.

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CHAPTER ONE

INTRODUCTION

This project is about industrial conveyor belt counting system. A conveyor belt mainly consists of two end pulleys with a continuous loop of material (usually flat and wide belt) that turns on about the pulleys. The involving pulleys are motor powered. The rotating effect of the set-up keeps moving the belt and any material or load on the belt forward. Therefore, the belts are extensively used for industrial and agricultural materials or products transportation. This system is evident in coal mines. In addition, bottling companies use such technique in transporting their drink in sensitive parts of the factory; hence, it has a significant importance in industrial automation. [1]

1.2 PROJECT OBJECTIVES

The basic drive or motivation for this project is not far fetched; it is borne out of the desire to create a well-organized and monitored production line.

In most industries, goods are usually produced en-masse and later packaged into units or reduced into units that could be easily quantified by counting. The result obtained after counting, gives the company better information on the exact quantity of goods it has produced. From this, the company can deduce correctly the cost of producing a unit of its product and can further draw up estimate of the expected income from the overall sale. The effect of these errors could in the long-run affect the net profit of the company, negatively.

Industrial conveyor belt counters are great item to have in any new company that is in the business of creating or fabricating products. With such a device, it will be possible to know the present output of a workstation. This information would be useful for any management seeking to increase productivity or see why productivity has decreased. For an existing company, conveyor belt counters could be implemented for a strategy using continuous improvement. This will show when different workstations have reached their goals.

Furthermore, the project is aimed at the design and construction of an electronic device that not only counts but provides an effective control mechanism and little human labor merits.

1.3 METHODOLOGY / CONSTRAINTS

The machine is incorporated with a light sensor set-up. This set-up holds a light emitting diode (LED) straight light source in form of Light Beam. The energy beam is in line with a light sensor (a light dependent resistor, LDR). Therefore, whenever the light from the emitter is stopped or blocked from reaching the sensor, there is a count increment of the machine digital display unit. The set-up is fixed across the passage of the belt system. The placement is done in such a way that moving products or items on the conveyor belt cut through the light beam. Whenever that happens, there is always an up count by the machine. It is quite obvious that the number counted by the machine simply represents the number of items or products that have passed through the conveyor transport system. The counting is digitally done through the break signal from the sensor. The involving digital circuit holds control latches, Up BCD counters and 7-segment decoders.

In addition, the design features a mode whereby the conveyor belt system is directed to automatically stop whenever the number of products or items counted is the same with a pre-inputted number. This feature helps to monitor production rate in a process and also enhances packaging automation.

In spite of the magnanimous benefits attributed to this work, a great deal of mental work and consultations were carried out before the arrival at the desired result . Hence, it is note worthy to mention here a few people who contributed to the work; they include Mr. Seun Ajagbe, a graduate of Mechanical Engineering who was instrumental in the casing and packaging of the circuit after construction. In addition, literatures consulted during the course of this work include "Design and Construction of a Preset Counter by Mbanu Justin, Department of Electrical Computer Engineering, Federal University of Technology Minna, and November 2004" and a host of other literatures listed in Reference page of this work.

1.4 SCOPE OF PROJECT WORK

This work involves the description of the various units that make up the system i.e. the power unit, the motion sensor unit, the control logic unit, the comparator unit and the counter/display unit as well as the theories backing them. This work also gives account of the different components that were used in the construction of the entire system, in addition to their configuration and mode of operation. It also explains how the construction was carried out, problems encountered, recommendation for future improvement and reference materials consulted during the course of the work.

CHAPTER TWO

REVIEW OF LITERATURE

Conveyor mechanisms are used as components in automated distribution and ware housing. In combination with computer controlled pallet handling equipment, this allows for more efficient retail, wholesale, and manufacturing distribution. It is considered a labour saving system that allows large volumes to move rapidly through a process, allowing companies to ship or receive high volumes with smaller storage space and with less labour expenses.[1]

The history of this technology came about as a result of Industrial revolution. The Industrial revolution was the major technological, social, economic and cultural change in late 18^{th} and early 19^{th} century that began in Britain and spread through out the world. During that time, an economy based on manual labour was replaced by one dominated by industry and the manufacture of machinery. [2]

The date of the Industrial Revolution is not exact. Eric Habsbawm held that it "broke out" in the 1780s and wasn't fully felt until the 1830s or 1840s, while T.S. Ashton held that it occurred roughly between 1700 and 1830 (in effect the reigns of George III, The Regency, and George IV).

The First Industrial Revolution merged into the Second Industrial Revolution around 1850, when technological and economic progress gained momentum with the development of steam powered ships and railways, and later in the nineteenth century with the internal combustion engine and electrical power generation [2]

It has been argued that GDP per capital was much more stable and progressed at a much slower rate until the industrial revolution and the emergence of the modern capitalist economy, and that it has since increased rapidly in capitalist countries than the socialist states.[2]

The causes of the Industrial revolution were complex and remain a topic for debate with some historians seeing the Revolution as an outgrowth of social and institutional changes brought by the end of feudalism in Britain after the civil war in the 17^{th} century. With the technological advancement, the percentage of children who lives past infancy rose significantly, leading to a larger work force. The Enclosure movement and the British Agricultural revolution made food production more efficient and less labour-intensive encouraging the surplus population who could no longer find employment in agriculture into cottage industries such as weaving and in the longer term into the cities and the newly developed factories. The colonial expansion of the 17^{th} century with the accompanying development of international trade, creation of financial markets and accumulation of capital are also cited as factors, as is the scientific revolution of the 17^{th} century.[2]

Hence, the development of conveyor belt system was necessitated by the act of industrial mass production. The need for a technology for the transportation of the required loads during the process is quite of great importance. The main results are reduced cost of production, increased safety and good control of products [2]

The conveyor belt system consists of a continuous moving belt (usually flat belt) that carries materials or packages from one place to another. This belting system is also used in conveyor transport system such as moving sidewalks or escalators, as well as on many manufacturing assembly lines [1]

The conveyor belting system uses reciprocating planks to move cargo through the floor. Also, in contrast, is a roller conveyor system which uses a series of rotating rollers to convey boxes or pallets. The conveyor belt dimensions are often flexible to match the user's specifications or application needs. The belt material and pattern vary for specific uses such as roofing stones conveying, bakery oven belts for pies and pizzas, extracted gravel transport and so on. Conveyor belts are available for a wide array of applications and transportation and more often application specific.

Primarily, these conveyor belts are more useful commercially than for local purpose. Moreover, belts are designed in such a way that they serve a specific industrial purpose. The agricultural belting system is designed for agricultural applications like transporting fodder and various farm equipments whereas retail belting system is generally used for transferring inventory. Construction conveyor belting system is designed for transporting of heavy stones or plywood but forest conveyor belts are designed for carrying logs, trees products and other related products.

The widely used and the most popular conveyor belt system is power transmission applications like engine belts, belts for power take-offs and industrial machineries. They are basically used to transfer heavy and bulky machines to the designed spot. These conveyors belts are generally made of a tough and strong material, making them able to carry heavy load with ease. [1]

2.3 HISTORY AND DEVELOPMENT OF COUNTER

An interesting feature of the project is the counting operation of the moving or transporting products or items on the conveyor belt. Counting application allows digital necessity from human history. Soon after language developed, it is safe to assume humans began counting. And that fingers and thumbs provide nature's abacus. The decimal system is no accident. Ten has been the basis of most counting systems in history. When any sort of record is needed, notches in a stick or a stone are the natural solution. In the earliest surviving traces of a counting system, numbers are built up with a repeated sign for each group of 10 followed by another repeated sign for 1.

In Egypt, from about 3000BC, records survive in which 1 is represented by a vertical line and 0 is shown as ^. The Egyptians write from right to left, so that number 23 becomes III^^. While, in the 1700BC, the Babylonians used a numerical system with 60 as its base. This is extremely unwieldy, since it should logically require a different sigh for every number up to 59 (just as the decimal system does for every number up to 9). Instead, numbers below 60 are expressed in clusters of ten, making the written figure awkward for any arithmetic computation.

The abacus emerged in the first millennium BC[11]. This method of calculation – originally simple furrows drawn on the ground, in which pebbles can be placed – is believed to have been used by Babylonians and Phoenicians from perhaps as early as 1000BC. The Romans numerals were used from the third century BC.

Our own century has introduced another international language which most of us use but few are aware of. This is the binary language of computers. When interpreting coded materials by means of electricity, speed in tackling a simple task is easy to achieve and complexity merely complicates. So the simplest possible counting system is best this means one with the lowest possible base – rather than 10. Instead of zero and 9 digits in the decimal system. So the binary equivalent of 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 are 1, 10, 11, 100, 101, 111, 1000, 1001, 1011, 1111 and so ad infinitum.[11]

In addition, the invention and development of digital electronics that work on binary designations, more and more logic units are designed for counting operations. They can be interfaced with the computer for easy-to-use applications. The latest chip making process tremendously drops the cost of counting component due to reduced size and material.

2.3 THEORITICAL BACKGROUND

Below is a block schematics of the Conveyor belt counting system:

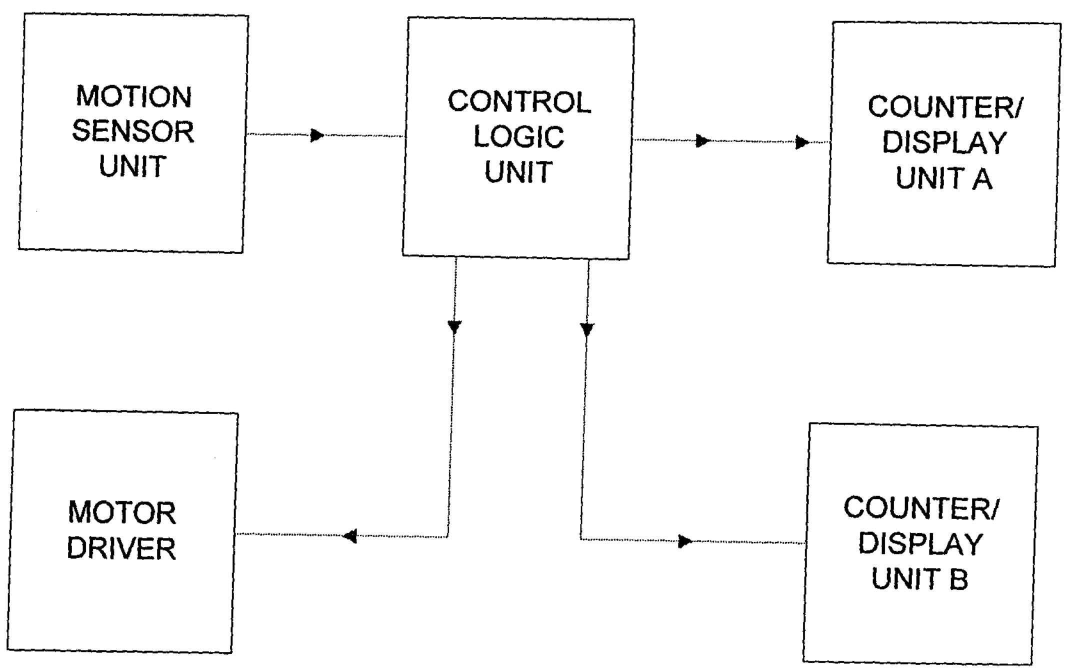


FIG. 2.1 BLOCK DIAGRAM OF DEVICE

The entire circuit of conveyor belt counting system can be divided into six (6) major units or groups. They are: -

(1) Power supply unit

(2) Motion sensor unit

(3) Control logic unit

(4) Comparator

(5) Counter/Display a unit

(6) Counter/Display B unit

(7) Alarm unit.

2.3.1 POWER SUPPLY UNIT

The power supply unit involves both 5V and 12V voltage outputs. A 24V A.C. step-down transformer is used to drop down the A.C. mains. The 24V A.C output from the transformer is rectified by a convectional bridge rectifier. The rectifier holds four (4) rectifying diodes (IN4001). The rectifier circuit requires two diodes to be active or forward biased in every half cycle of the input alternating voltage or current while the other two are cut-off through reverse biased [9]

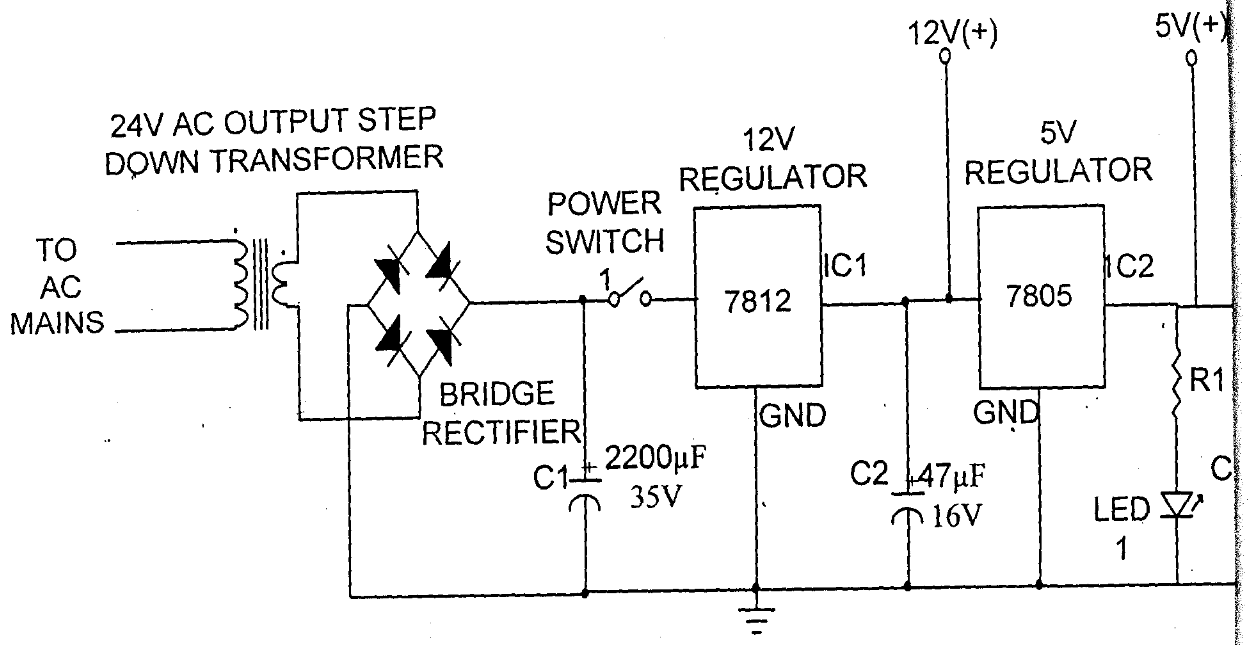


FIG. 2.2 POWER SUPPLY UNIT

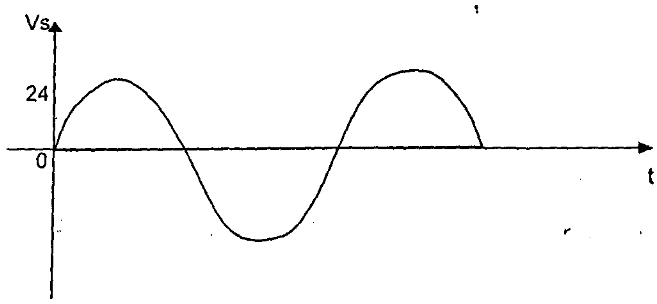


FIG. 2.3a OUTPUT WAVEFORM OF SUPPLY BEFORE RECTIFICATION

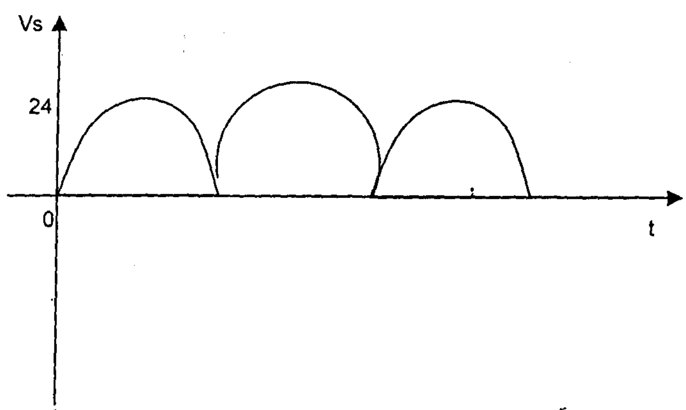


FIG. 2.3b OUTPUT WAVEFORM OF SUPPLY AFTER RECTIFICATION

Terminal Y and X of the circuit of Figure 2.2 are positive and negative terminals respectively. The positive terminal is where two N terminals of two diodes meet. Point X is the terminal where two positive sides of two diodes meet. It is therefore the negative terminal of the supply. The bridge rectifier in parallel with a 2200μF 35V filter capacitor. This capacitor removes ripples or residual A.C. component in the output of the rectifier. A power switch is incorporated to open or close the complete circuit. It might be a mere toggle switch. 7812 and 7805 are regulator integrated circuits that produce regulated 12V and 5V respectively. Sometimes, a 47μF capacitor is connected in parallel with the output of a particular regulator. The capacitor is incorporated to smoothen the flow of electric current through the circuit altogether [9].

A light indicator circuit is used to show the presence of electric power in the circuit. It involves a Light Emitting Diode (LED) and a 1KΩ resistor (current limiting resistor). The two devices are connected in series. The resistor merely allows a suitable voltage of about 2.8V to be across the Light Emitting Diode (LED) from 5V of 7805 [4].

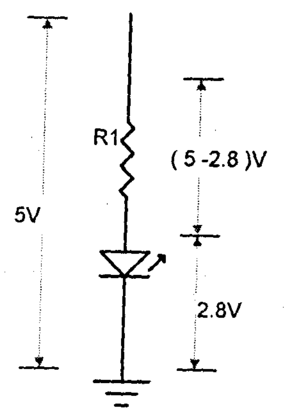


FIG. 2.4 LED AND CURRENT LIMITING RESISTOR R1

Therefore the voltage across R_L is $5 - 2.8 = 2.2V$

Assuming a typical current of 2mA flow in the circuit

$$R_L = \frac{2.2}{2 \times 10^{-3}} = 1100\Omega$$

$1000\Omega \approx 1100\Omega$

$1K\Omega$ is more of practical importance as compared to $1.1K\Omega$.

2.3.2 THE MOTION SENSOR UNIT

The main function or focus of this project is to count the flow of items or objects through a conveyor belt. The item or objects are counted by crossing a light motion sensor unit. This unit involves a light emitting diode (LED) and light dependent resistor (LDR) circuit. The light indicator illuminates the light dependent resistor (a light sensor). The moving items or an object on the conveyor belt breaks the light beam or ray from reaching the sensor. The circuit recognizes the disturbance and responds accordingly.

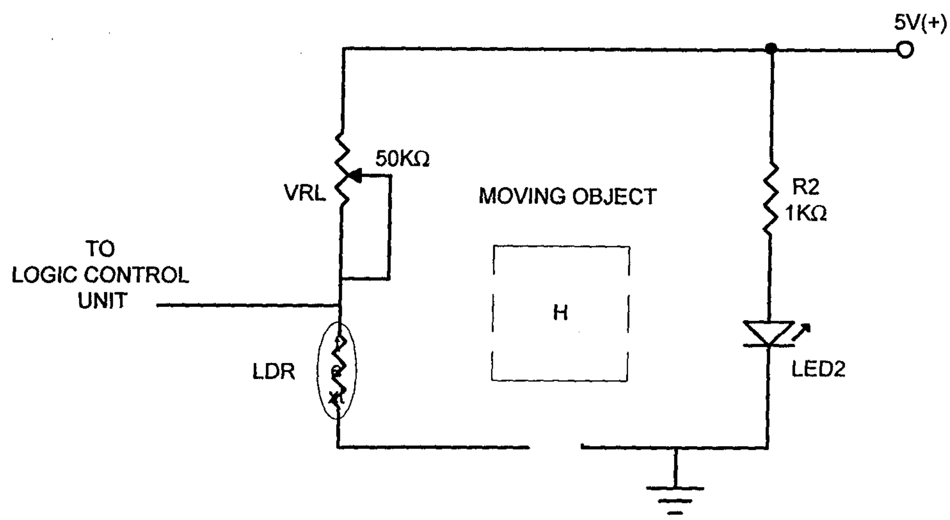


FIG. 2.5 OBJECT PASSING THROUGH THE LIGHT SENSOR UNIT

A Light Dependent Resistor (LDR) has a very high internal resistor running into 200KΩ in dark condition[9]. But, in considerable illumination, the resistor drops to as low as 2KΩ. This characteristic of Light Dependent Resistor is the basis of the light sensor unit.

LED 2 is in series with a 1KΩ resistor for current limiting just like the power indicator circuit. As earlier explained, LED 2 illuminates the LDR 1. It is worth noting here that in previous work done on something similar to this project, infrared beam and sensor was used for the motion sensor unit but in this work in focus, a Light Dependent Resistor ad Light Emitting Diode are used because of cost and availability.

VR 1 (50KΩ) is used to vary the sensitivity of the set-up. Assuming it is adjusted to 20KΩ then LDR is at 2KΩ, whenever illumination occurs as shown below.

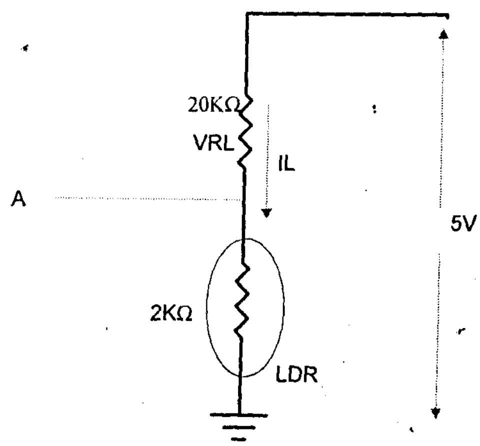


FIG. 2.6 THE RECIVER CIRCUIT OF MOTION SENSOR UNIT DURING CONSIDERABLE ILUMINATION

The current flowing in the circuit I_L is given as:

$$I_L = \frac{5}{(20+2) \times 10^3} = \frac{5}{22 \times 10^3} = 0.2mA$$

Therefore, during illumination of the sensor, the voltage at point A with respect to the ground is given below.

V_{A1} = LDR_1 x 0.2mA

= 2 x 0.2mA = 0.4V

V_{A1} is merely grounded or negative for more practical purposes, V_{A1} is at logical 0.

But whenever an object obstructs the illumination of the sensor, a dark condition on the LDR: the situation is inverted. LDR_1 should be around or over 200KΩ at that situation.

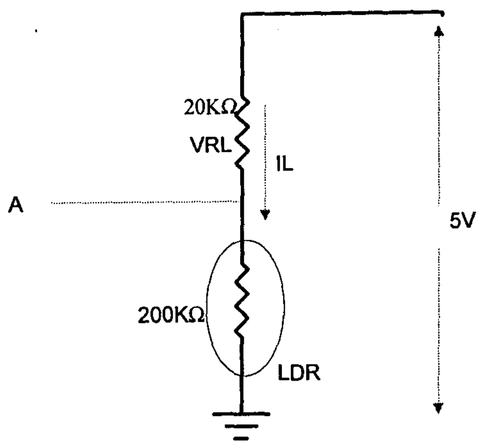


FIG. 2.7 THE RECIVER CIRCUIT OF MOTION SENSOR UNIT DURING DARKNESS CONDITION

The effective resistance of VR_1 and LDR_1 is (20 + 200) KΩ = 220KΩ

Therefore, the current flowing in this situation is given below.

$$I_D = \frac{5}{220 \times 10\text{^}3} = 2.27 \times 10^{-5} A$$

I_D = 0.0227mA

The voltage at terminal A with respect to ground is given below:

$V_{A2} = I_D \times I_{DR\,1}$

$= 0.0227 \times 10^{-3} \times 200 \times 10^{3} = 4.5V$

Therefore, terminal A is at a high logical level, for more technical importance.

an object through the conveyor belt. Logic 0 at this same terminal shows no object situation at the sensor. These logical levels are used for counting process. Terminal A is fed into the control logic unit.

2.3.3 THE CONTROL LOGIC UNIT

The control logic unit is the heart of the entire circuit. It controls every operation in the circuit. It controls the signal from the motion sensor into the related counter, the two counter, and motion circuits. The unit embodies major both 4013B and 4060B. They form the input control latch, control oscillator and output control latch operations.

Terminal A of the motion sensor is connected to the input control latch (a 4013B). The logical device is supported by a 4060B (control oscillator).

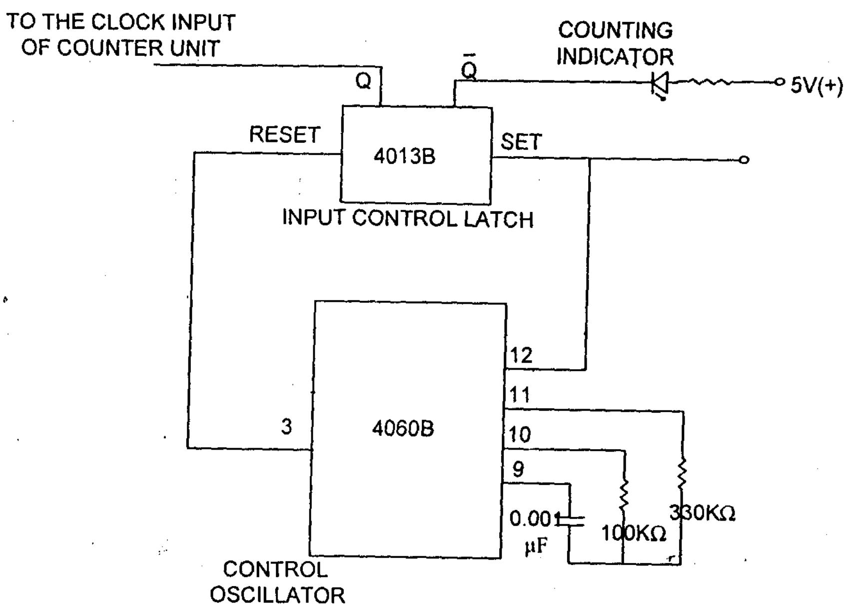


FIG. 2.8 CONTROL LOGIC UNIT

The function of the input section of the control logic unit is to smoothen the flow from the motion sensor to counter 1 display a unit. If the signal from the motion sensor is directly connected to trigger counter/display unit, a significant error is obvious to happen.

The result might be multiple counts instead of single increment. This input unit times the counting operation to remove multiple counting errors.

Based on the truth table of an SR flip-flop or latch shown in Fig 2.9 below, whenever the set input is logical high while the next terminal is low, the Q output is logical 1 and Q low: Therefore, the Q output is only at high logic level whenever an object is detected through the conveyor belt set-up. When an object is detected, the Q output is low logic level and Q high [6]. The condition is related to resetting operation on the latch or flip-flop. The operation is achieved by the control oscillator. The integrated circuit (4060B) on enabling input (pin 12), it disenables the complete integrated circuit when high logical level is attained. The oscillator is active whenever Pin 12 is at low logical level.

The control oscillator resembles a timer. It reset the input latch within short moment after it is set by the motion sensor unit. The control oscillator's timing operation is determined by its RC configuration. The values of both capacitor and resistor at Pin 10 and 9 respectively are mostly concerned with the timing.

Based on the datasheet of the device, the main frequency is given below:

$$f_m = \frac{1}{2.3R_C} = \frac{1}{3.3\times10^{3}\times0.00\times10^{6}} = 13.2KH$$

The RC value is quite typical of such application. Therefore the frequency output form Pin 3 is given below:

$$f_{Pin3} = \frac{f_m}{2^{14}} = \frac{13.2\times10^{3}}{2^{14}} = 0.81Hz$$

The timing for the reset operation is:

$$\frac{1}{f_{pin15}} = \frac{1}{0.81} = 1.234 seconds$$

The timing is quite of theoretical importance. A more practical value should be higher.

Therefore, the input side of the logic control unit holds the signal from the motion sensor in minimizing multiple counting error.

The output side of the logic control unit deals with the motor controlling or switching aspect. The motor is DC type. It drives the conveyor belt system. This part s better explained at the comparator section of the chapter.

Again it is worth noting that, instead of a 4060B IC, a 555 timer could be used. In most previous works on industrial counters, 555 timer ICs are used to provide control oscillation but why I chose 4060B IC is better explained in chapter 3 under my design analysis.

2.3.4 THE COMPARATOR UNIT

The comparator unit mainly involves an exclusive OR gate circuit[10]. The circuit compares the Binary Coded Decimal (BCD) cases from both counter A and B. That is< the codes from the preset table counter and the motion sensor's counter.

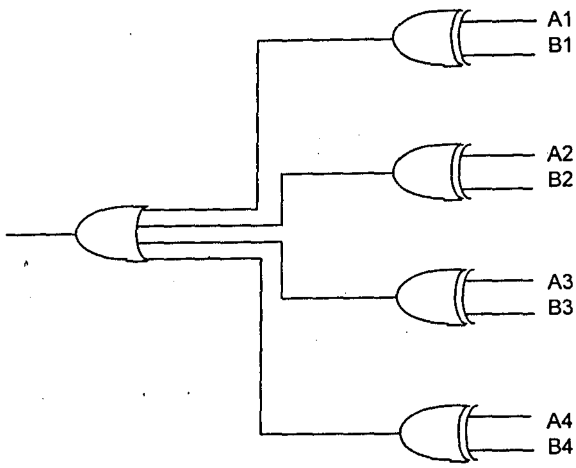


FIG. 2.9 COMPARATOR UNIT

The circuit is a simple one; it involves code A and B from the counters. Whenever the two codes are the same, the output of the 4-input OR gate (a bumming device) is low logical 0. These shows the two codes are one and the same. Whenever the state of the codes is not the same the output is always logical 1. The output of the comparator is used for controlling the output or motor control unit. The main concept is the truth table of the exclusive OR gate shown below.

TABLE: 2.8TRUTH TABLE OF EXCLUSIVE-OR GATE.

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

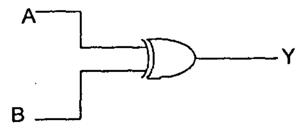


FIG.2.10 EXCLUSIVE OR-GATE

2.3.5 COUNTER DISPLAY A

This unit involves two BCD 4518B counters. They are asynchronously cascaded in parallel. The counters provide a maximum count of 99. Each counter has a corresponding 7-segment decoder (4511B) [6]. These two resulting display units are aimed to display the corresponding digits on 7-segment display panels. The displays are common cathode in nature. Current limiting resistors are connected in between the decoders and display in order to supply a suitable voltage across each segment of the display.

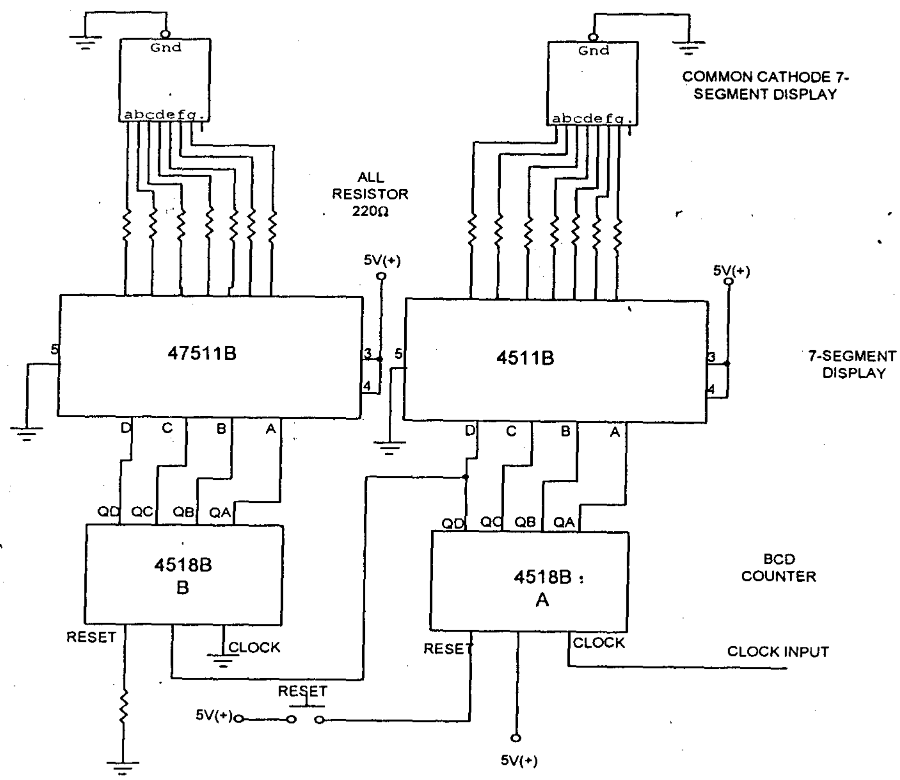


FIG. 2.11 COUNTERS DISPLAY UNIT

Each 220Ω resistor connected between the output of every output from the decoder and the corresponding segment of the 7-segment display is aimed to provide 2.7V across the corresponding segment from the 5V power supply. Each segment of the display requires at most 2.7V for operation. Over powering the light devices causes definite destruction.

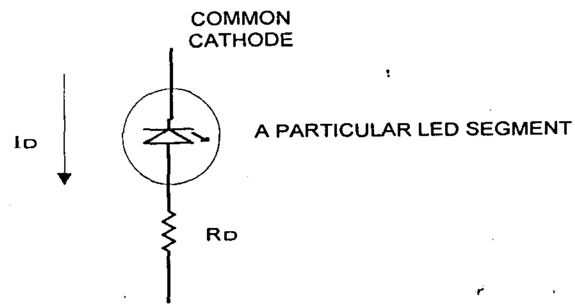


FIG. 2.12 THE CIRCIUT OF A PARTICULAR CURRENT LIMITING RESISTOR OF A SEGMENT

The involved Light Emitting Diode (LED) requires around 2.7V for operation.

Therefore, the voltage expected across the resistor R_D is $5 - 2.7 = 2.3V$.

Taking a typical current of 9mA through the series connection,

The value of $R_D = \frac{2.3}{9\times10^{-3}} = 255\Omega$

220Ω is of more practical value as the resistance is quite a standard. Therefore, the resistor is put in series with each segment terminal.

The output signal or clock from the motion sensor unit is fed to the clock input of the LSB counter. The cascading connection between the two devices is from the Q_D output of the LSB counter to the clock enable of the MSB counter. The reset of both counter are connected together. A 10KΩ resistor is used for connecting the common reset terminal to the ground. The resistor value could be from 1 – 1000KΩ range. The resistor functions to keep the terminal low. Pressing the reset button gives the point a high logical level, which eventually clears or returns every counter to zero level.

Moreover, the clock or pulses signal from the motion sensor causes increment on the counter on every arrival. And the reset switch when activated results into zero, all display.

2.3.6 COUNTER DISPLAY B

This unit is one and the same with the earlier one. The difference is that, its clock input is connected to a low signal from the oscillator. A switch connects the pulse from the oscillator to the clock input when pressed.

From the frequency formula of the 4060B

$$f_{pin2} = \frac{13.2\times10^3}{2^{13}} = 1.6Hz$$

$$T_{PIN2} = \frac{1}{1.6Hz} = 0.62\ seconds$$

The value is more theoretical than practical. In real situation, the involved pulse is much slower because of the accuracy of the 4060B integrated circuits formula. The circuit holds a reset switch like the other, everything is just the same.

2.3.7 ALARM UNIT

The alarm unit is incorporated into the device to call the attention of its user or operator. It involves a 4060B oscillator to generate two different audio signals. One of the frequencies is high while the other is relatively low.

CHAPTER THREE

3.1 DESIGN ANALYSIS

The project is aimed at a reasonable simplicity, therefore, the involved electronic components are quite cheap, compact, flexible, low power consumption and readily available. These leading advantage coupled with intense information about the related components, made the design of the circuit an easy one.

In addition, the integrated circuits used are all complementary metal oxide semiconductor (CMOS) type. The logic class of these ICs provide suitable characteristic (some included in chapter two above) for a simple and cheap design. The integrated circuits are placed under the CMOS 4000 series. This logic series holds numerous functions for almost any design.

3.2 COMPONENT CHOICE

As stated above, the involved electronic components are CMOS type. CMOS integrated.circuits are preferable to Transistor Transistor Logic type. Transistor Transistor Logic (TTL) is attributed to high power consumption, missing logic functions, less dense, chip and fixed power supply. These features are not favorable for this particular design with respect to CMOS attachment. For instance, 4000-series CMOS operate with 3 – 18V power supply, while 7400-series TTL malfunction under a 5V power supply. The additional features of the logic group, such as very low power supply provide extremely good choice for this particular design in area of economy.

3.3.0 COMPONENT DESCRIPTION AND USAGE

The design embodies the following electronic components:

4060B

4013B

4070B

4518B

4511B

2SD400

2SC945

1N4001

Common cathode seven-segment display.

3.3.1 4060B

The 4060B is a 16-Pin CMOS 14-stage counter/oscillator/divider integrated circuit. It is designed to generate ten (10) different frequencies from a practical high one. The oscillator can be configured both in RC and crystal mode. The RC configuration used in this work. The integrated circuit is far better than the common 555 timer in numerous ways, one of which is the multiple frequency outputs associated with the 4060B, but the 555 timer is not capable of performing such function [6].

The Pin 12 of the 4060B is made logic 0 for enabling whenever high local level is applied to the pin; all the frequency outputs are reset. In addition, its whole outputs are buffered. This feature protects the integrated circuit from destruction due to static charge.

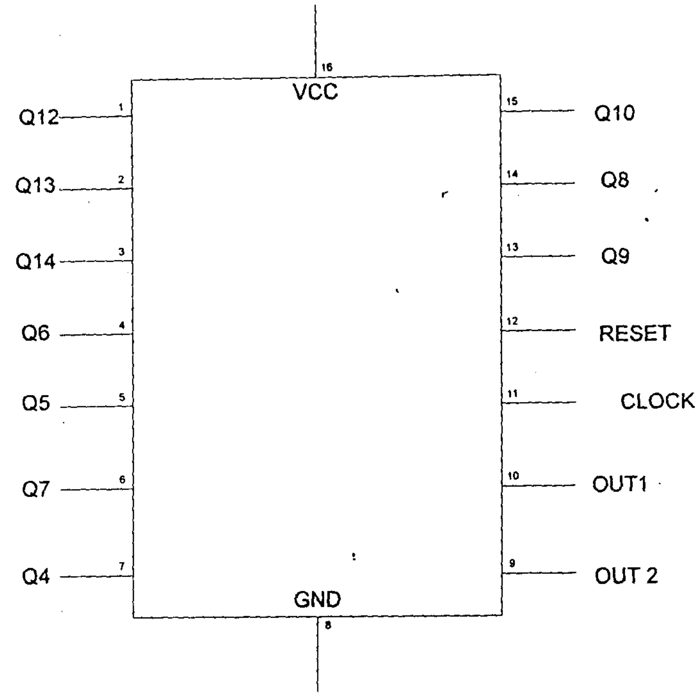


FIG. 3.1a FUNCTIONAL DIAGRAM OF TRHE 4060B I

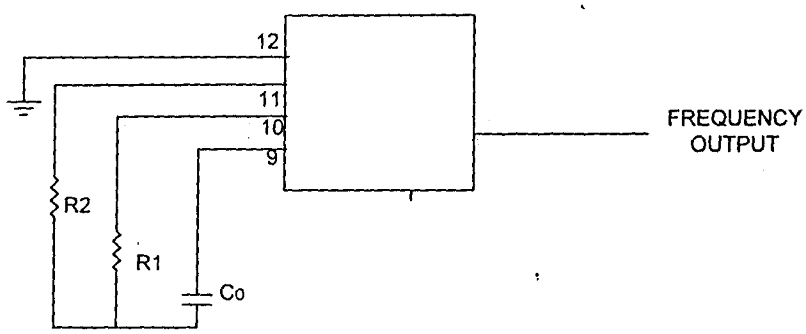


FIG. 3.1b THE NORMAL RC CONFIGURATION OF THE 4060B IC

The oscillator provides a frequency or pulse which works under the following frequency formula: $f_m = \frac{1}{2.3R_1C_0}$

$$1KHz \leq f \leq 100KHz$$

The relationship between R_1 and C_2 is given below

$2R_1 f_C < R_2 < 10R_{tc}$ [3].

(f in Hz, R in ohms, C in farads)

f_m is divided fourteen (14) times inside the integrated circuit through a fourteen stage divider/counter logic unit. Ten of the frequencies are fed out of the integrated circuit.

The frequency output from a particular output terminal is given below:

$$f_{qx} = \frac{f_m}{2^x}$$

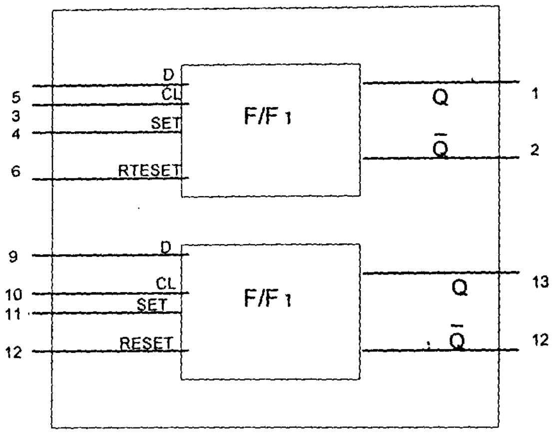
X is the Q value of the particular output terminal or Pin. For instance, Pin 3 is Q_{14} and assuming f_m is 1000Hz, therefore

$$f_{QX} = \frac{1000}{2^{14}} = 0.06Hz$$

The same step is applicable to other output terminals.

3.3.2 4013B

The 4013B IC is a 14-Pin CMOS dual D-type latch or flip-flop integrated circuit. The single integrated circuit contains two identical D-type latches or flip-flops. Each holds SET and RESET features alongside the D-clock logic function. The 4013B is used for shift register, counters control circuits application in this project design. A common application is the SR mode. The D mode involves the clocking of the flip-flop and the logic of the D input is transferred to the Q output at the positive edge of the clock [3].



Pin 16 Vdd (+)

Pin 8 Vss (-)

FIG. 3.2a FUNCTIONAL DIAGRAM OF THE 4013B SHOWING THE INVOLVED FLIP FLOPS.

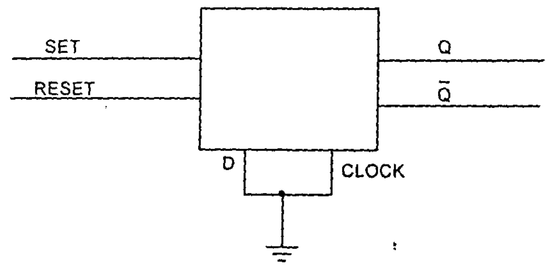
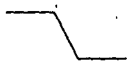


FIG.3.2b THE SR MODE OF A SINGLE FLIP-FLOP

TABLE: 3.2 TRUTH TABLE OF THE 4013B IC

CL	**D**	**R**	**S**	**Q**	**$\overline{Q}$**
	0	0	0	0	1
	1	0	0	1	0
	X	0	0	Q	$\overline{Q}$
X	X	1	0	0	1
X	X	0	1	1	0
X	X	1	1	1	1

Logic 0 = low, logic 1= high, logic x= don't care

3.3.3 4070B

The 4070B is a quad exclusive 2-input OR-gate[8]. That is, the integrated circuit holds four (4) 2-input OR-gat. They are identical and follow the common quad Pin layout.

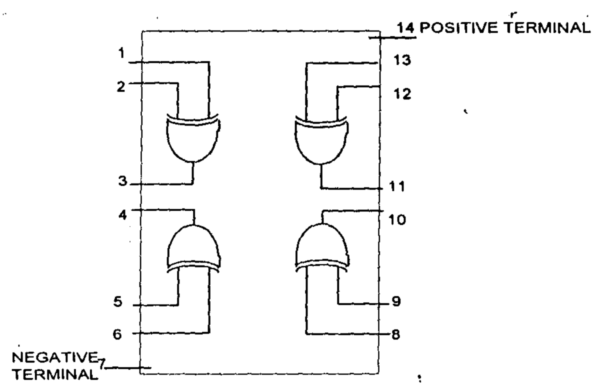
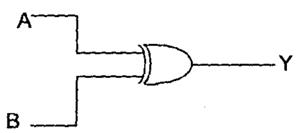


FIG. 3.3 FUNCTIONAL DIAGRAM OF THE 4070B

TABLE: 3.3 TRUTH TABLE OF THE 4070B

A	B	C
0	0	0
0	1	1
1	0	1
1	1	0



A single 2-input exclusive OR gate

3.3.4 4518B

The 4518B is a dual BCD UP counter [8]. A single integrated circuit, which holds two independent BCD Up, counter. Each counter possesses internal synchronization stage. Therefore, they provide a good clocking response. The counter stages are D-type flip-flop having interchangeable clock and ENABLE lines for incrementing in either the positive or negative transition of the clock. The counters are cleared by high levels in their RESET terminals. The counters can be cascaded in the ripple mode by connecting Q_4 to the ENABLE input of the subsequent counter while the clock input of the latter is hold low. The medium-speed operation is typically 6MHz.

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

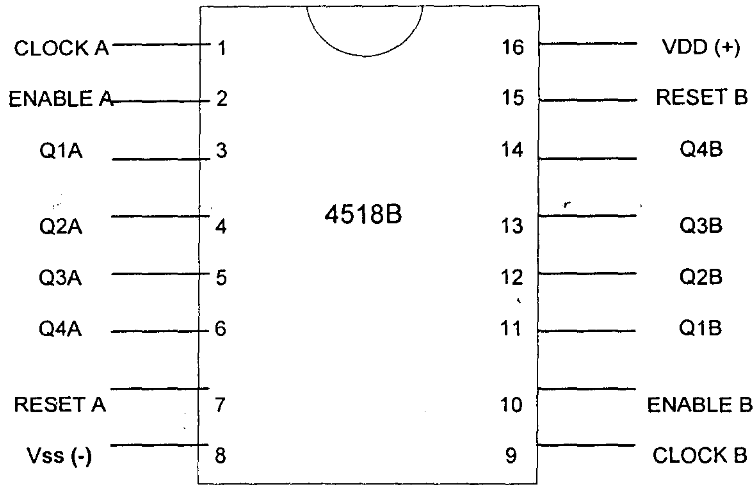
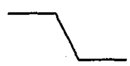


FIG. 3.4 PIN ASSIGNMENT OF THE 4518B IC.

TABLE: 3.4 TRUTH TABLE OF 4018B

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

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

3.3.5 4511B

The 4511B is a 16-Pin CMOS latch/BCD to 7-segment decoder integrated circuit. It is designed with bipolar outputs for high current rating displays or loading application [8]. The device possesses both lamp test (IT), Blank (BL) and Latch Enable or Strobe inputs for testing the display, shutting off and intensity-modulate it and storing or strobing a BCD code respectively. Several different signals may be multiplexed and displayed when external multiplexing circuitry is used. The integrated circuit is only compactable with common-cathode 7-segment display. This load is attributed to lower power consumption as compared to common anode type [3].

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

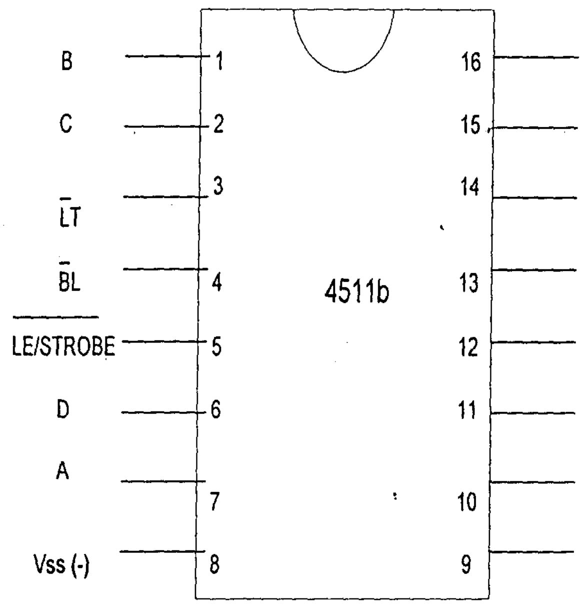


FIG. 3.5 TERMINAL ASSIGNMENT OF THE 4511B IC

TABLE: 3.5 CODE DISPLAY TABLE

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

3.3.6 2SD400

The 2SD400 is an NPN transistor with a related maximum voltage and current of 30V and 1A respectively. It is used for the switching operation of the motion unit.

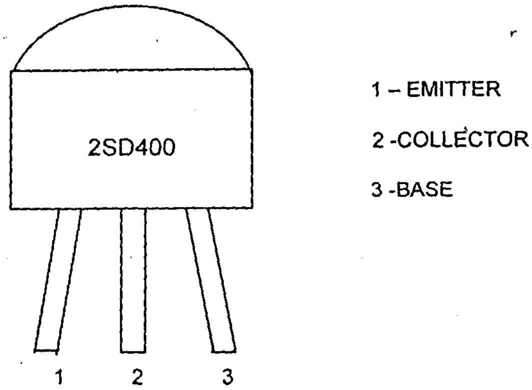


FIG. 3.6 PIN LAYOUT OF 2SD400 TRANSISTOR

The frequency outputs of the oscillator are given below:

$$f_{pin3} = \frac{f_m}{2^{14}} = \frac{\dfrac{1}{2.3\times33\times10^{3}\times0.001\times10^{-6}}}{2^{14}}$$

$$= \frac{13.2\times10^{3}}{2^{14}}$$

$$= 0.81\text{Hz}$$

$$f_{pin7} = \frac{f_m}{2^{14}} = \frac{\dfrac{1}{2.3\times33\times10^{3}\times0.001\times10^{-6}}}{2^{14}}$$

$$= 825\text{Hz}$$

These two frequencies are mixed and amplified by the 2SD400 transistor circuit in the common emitter configuration.

The resistances of the output speaker is 8Ω

The expected theoretical current of the collector of the transistor is given below:

$$I_C = \frac{V_{CC}}{8} = \frac{12}{8} = 1.5A$$

The real or practical value is for below this.

Therefore, $I_b = \frac{1.5}{100} = 0.015A$

The base resistance $= \frac{5}{0.015} = 333.33\Omega$

But, a base resistance of $1k\Omega$ is used to lower the base current. This is because the transistor in use has a maximum allowable current at the oscillator, I_C of 1A. Therefore, the output from the speaker is reduced or lower than expected. The reduction limits power consumption.

The alarm is triggered on by the enabling of the 4060B a J terminal through the Q output of the output control latch. The enabling is an active low action. Therefore, when the start button is pressed every output action is neutralized and the complete device is ready for a fresh counting operations.

3.3.7 2SC945

This 2SC945 is also an NPN transistor. It is designed for switching and audio amplifier functions in the circuit. Its maximum collector to emitter voltage V_{CEO} and collector current (I_C) are 50V and 100mA respectively.

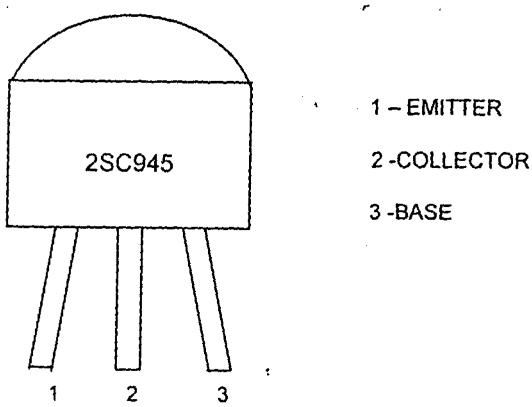


FIG. 3.7 PIN LAYOUT OF 2SC945 TRANSISTOR.

3.3.8 1N4001

The 1N4001 is a rectifying PN diode with maximum voltage and current rating of 50V and 1A respectively. Four of which are connected together to from the rectifying circuit of the power unit.

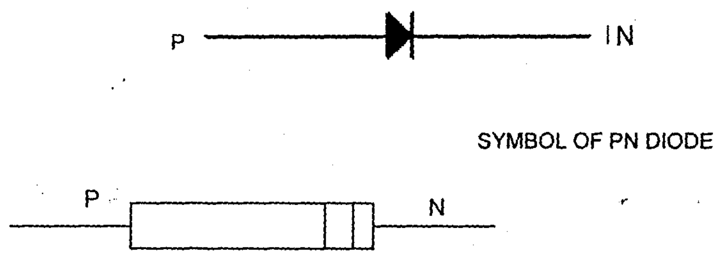


FIG. 3.8 PIN CONNECTION OF IN4001.

3.3.9 COMMON CATHODE SEVEN SEGMENT DISPLAY

The device is designed with Light Emitting Diodes (LEDs) to convert 7-segment codes into visual or decimal numbers. Two of them are used for this design. The are fed from the output from the decoders.

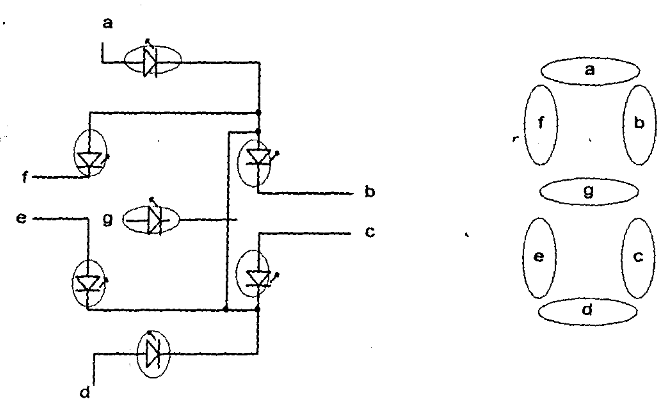


FIG. 3.9 PIN LAYOUT OF A COMMON CATHODE DISPLAY.

3.10 ALARM UNIT

As stated earlier in chapter two, the alarm involves a 4060B oscillator, which generates two different audio signals. One of the frequencies is high while the other is low.

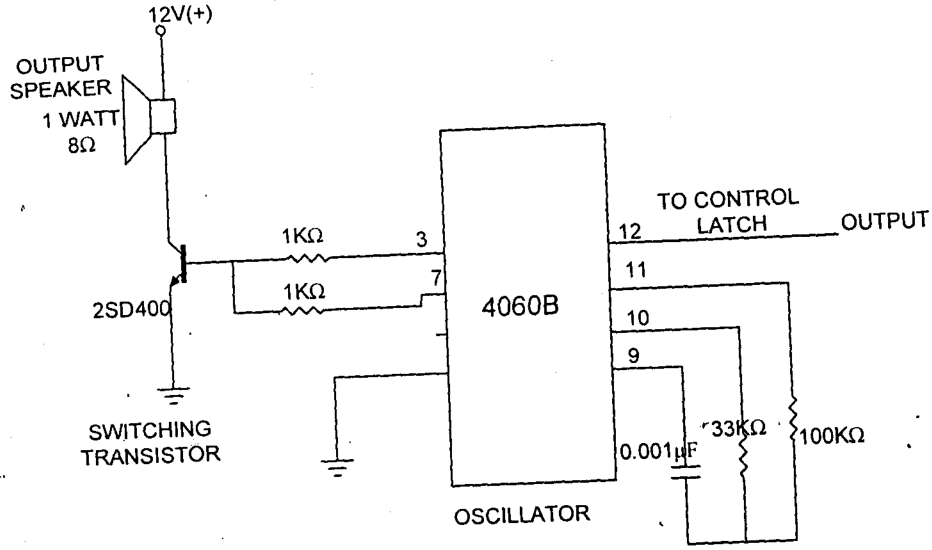


FIG. 3.10 ALARM CONFIGURATION

CHAPTER FOUR

CONSTRUCTION, TESTING AND RESULT

4.1 CIRCUIT CONSTRUCTION

The construction of the circuit was performed on bread board to determine its workability before mounting it on a Vero board. Before the involved integrated circuits were mounted on the Vero board, corresponding IC sockets were soldered into their respective positions. The involved sockets are protective devices for the integrated circuits which easily respond to heat. The other components such as 7-segment displays, transistors, resistors were directly put on the Vero board. The devices withstand heat from the soldering iron to a reasonable degree.

The components were laid out and connected with thin connecting wires according to the circuit design [see Appendix]. The connections of the wires were carefully done without unwanted circuit bridge. The connection was made on the Vero board in accordance to the circuit diagram[see Appendix] by putting more related components together for ease of connection. The connection was done with utmost care in order to avoid short circuits, especially at power terminals.

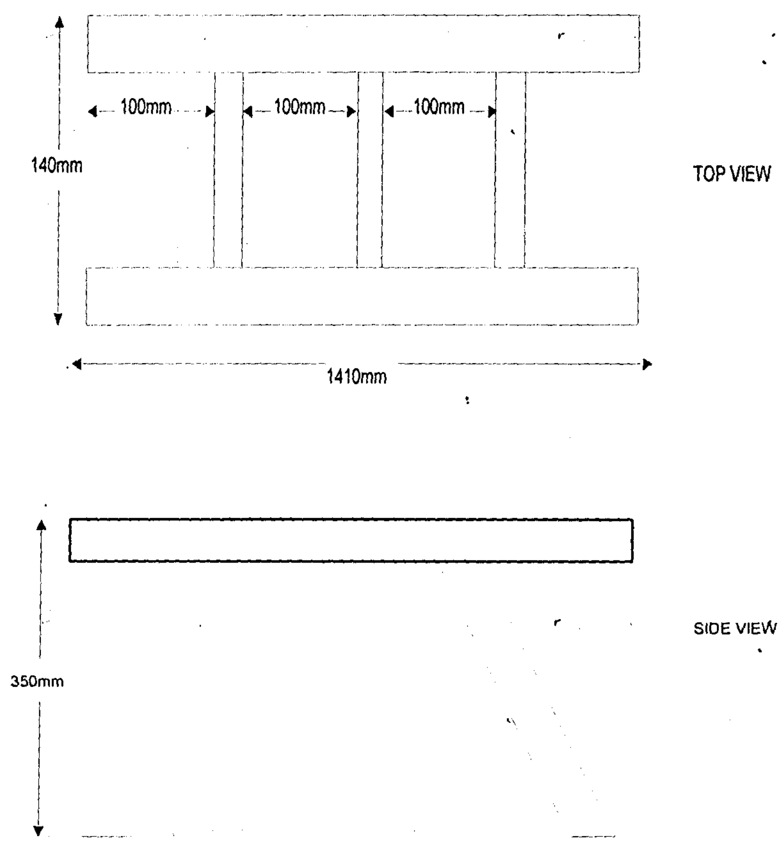
The main circuit was splitted into smaller groups. Each attachment was independently tested before the whole circuit was made one. The testing was done by searching for wrong connections. The main precaution was avoiding supplying power to the circuit before proper connection.

4.2 CASING CONSTRUCTION

The casing of the circuit was quite tasking because of the model nature of the project. The project involves two main casing or packaging. One part embodies the main circuit while the other is a conveyor belt set-up made of mild steel. The set-up involves welded part for rigidity. The structures holds a D.C. motor coupled with belt drive for achieving the conveyor belt system.

Another part of this assembly is the light emitter and receiver. The attachments are connected to the main circuit through wires. In fact the main circuit casing is attached to the conveyor belt structure or set-up for compatibility.

4.3 CASING DIMENSION



MOUNTING SETUP

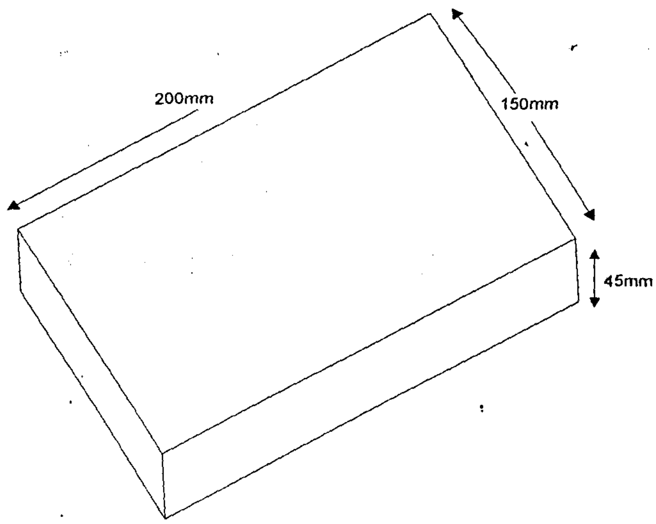


FIG. 4.1 CASING CONSTRUCTION SHOWING THE VARIOUS VIEWS

4.4 TESTING

The testing of the involved circuit or set-up was carried out to justify the workability of the project. Firstly, the circuit or connection was checked whether it is in good order. Then, the set-up was powered. A particular number was input into the preset counter. The conveyor belt was allowed to roll. At the same time, a light weight plastic bottle was placed on the conveyor. The bottle was allowed to pass across the light aided-motion sensor, placed at the edge of the belt system. The bottle was then brought back to the other edge of the belt system and again allowed to pass the motion-detector set-up. The operation was carried out at the number of the input into the preset counter. Every observation was noted and recorded for reference.

Moreover, many of such operation were carried out for different preset counter states.

4.4 RESULT

It was quite obvious that each time the bottle passed the light-aided motion monitor, or sensor, the count or number of conveyor belt counter incremented. The counting was attributed to no multiple count-errors, showing the importance of the input logic unit of the circuit. Counting was merely made each time the involved bottle crossed the motion sensor.

The D.C. motor of the conveyor belt system stopped moment after the two counters were at the same count or number. An alarm was triggered on to define the state. The outputs were neutralized when the start button was pressed. The button resets every output active action.

CHAPTER FIVE

5.1 CONCLUSION

The project simply demonstrates the significance of logic devices or generally electronics in industrial applications. Through mere light sensor-set-up and additional logic functions, objects moving along a conveyor-belt system can be digitally counted. The removal of usual count errors makes the design really reliable. Also, the automatic motor switching mechanism is another interesting feature of the complete design. The mechanism signifies the extent of electronics in control.

Despite the fact the project is all about modeling, it still reveals reasonable side real industrial situation. Due to the flexibility of the involved components or parts, the project can easily be modified into full scale application. Also, the maximum count could be increased for wide counts.

5.2 PROBLEMS ENCOUNTERED

i. The most evident difficulty as related to the project is the design and construction of the conveyor-belt model. It required high technical experience, hence external technical assistance was sort for successful result.

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

iii. Also, the motion-sensor unit was required to be shielded from external light sore, this is important in order to remove error.

iv. The conveyor belt motion-overrunning problem was rectified through applications of suitable gear reduction.

v. The Motors's circuit was interfering with the other parts of the circuit during the course of the design. Voltage regulators were incorporated into the design to remove the current instability.

vi. The acquisition of related components was initially difficult. Later most of the components were gotten from Lagos.

5.3 RECOMMENDATION

i. The project could be modified for computer interfacing application.

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

iii. A timer could be incorporated into the system so that, the operation of the conveyor belt is both time and counting based. It makes the work of more importance to real industrial situations.

iv. The design could be increased for greater counting operation.

v. The design could be modified for remote control application, in which the conveyor belt is remotely monitored.

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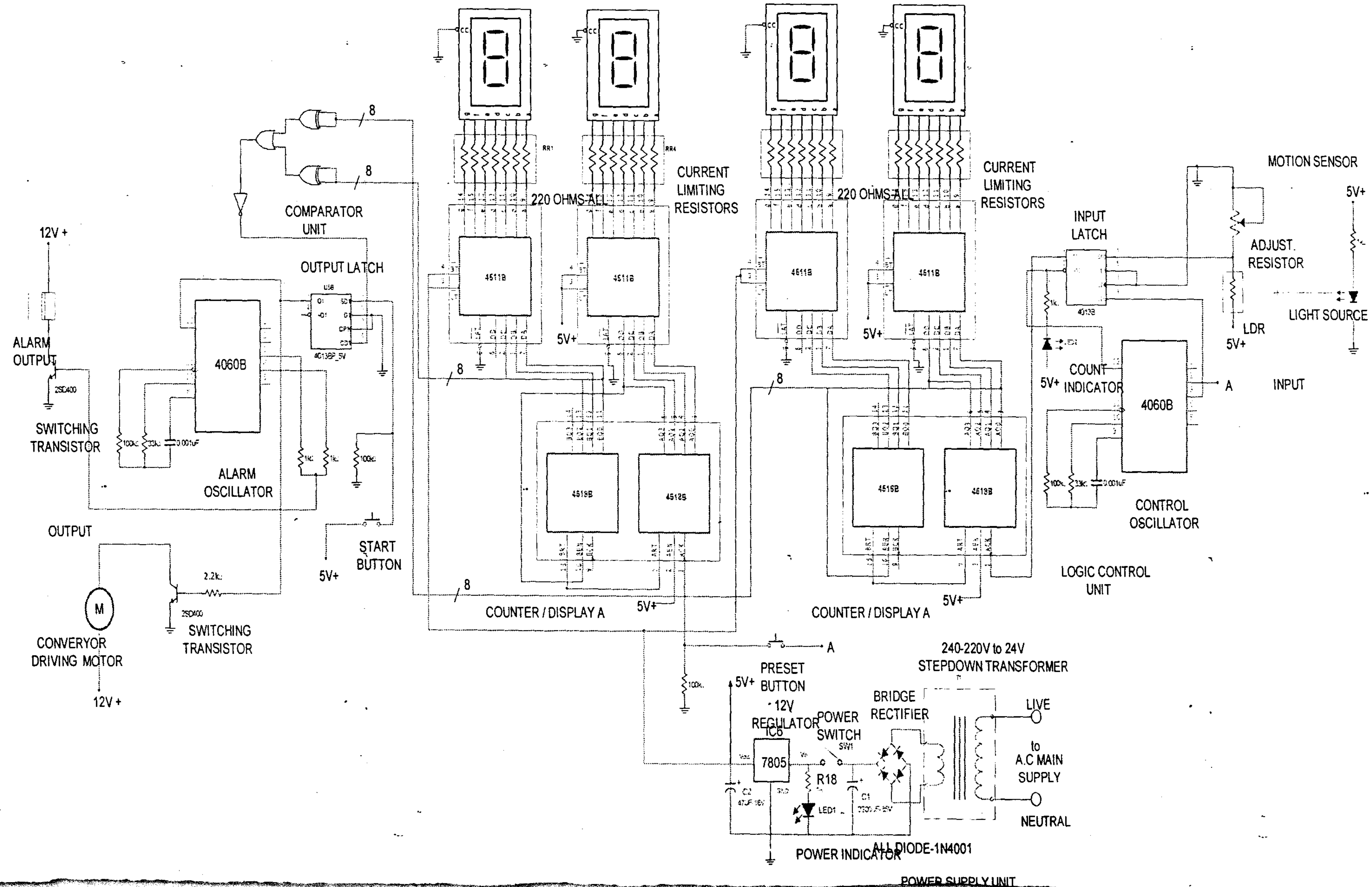
APPENDIX



COMPARATOR UNIT
OUTPUT LATCH
12V +
ALARM OUTPUT
4060B
SWITCHING TRANSISTOR
ALARM OSCILLATOR
OUTPUT
START BUTTON
5V+
2.2k
M
CONVERYOR DRIVING MOTOR
SWITCHING TRANSISTOR
12V +
220 OHMS ALL
CURRENT LIMITING RESISTORS
220 OHMS ALL
CURRENT LIMITING RESISTORS
4511B
4518B
COUNTER / DISPLAY A
COUNTER / DISPLAY A
INPUT LATCH
MOTION SENSOR
ADJUST. RESISTOR
LIGHT SOURCE
LDR
COUNT INDICATOR
4060B
INPUT
CONTROL OSCILLATOR
LOGIC CONTROL UNIT
PRESET BUTTON
240-220V to 24V STEPDOWN TRANSFORMER
12V REGULATOR
POWER SWITCH
BRIDGE RECTIFIER
7805
R18
LIVE
to A.C MAIN SUPPLY
NEUTRAL
POWER INDICATOR
ALL DIODE-1N4001
POWER SUPPLY UNIT