DESIGN AND CONSTRUCTION OF A PRESET COUNTER

BY

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A REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A BACHELOR OF ENGINEERING (B.ENG) DEGREE IN ELECTRICAL/COMPUTER ENGINEERING
DEPARTMENT OF ELECTRICAL/COMPUTER ENGINEERING
SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

NOVEMBER, 2004.

CERTIFICATION

The undersigned certify that this project by MBANU JUSTIN REG. NO. 99/9052EE has been approved as meeting the requirement of the Department of Electrical/Computer Engineering, Federal University of Technology, Minna.

PROJECT SUPERVISOR
~~ENGINEER~~ ABRAHAM USMAN

09-12-04
DATE

HEAD OF DEPARTMENT
ENGINEER M D ABDULAHI

9/12/2004
DATE

PROJECT CORDINATOR
ENGINEER P O ATTAH

DATE

DECLARATION

I, MBANU JUSTIN REG. NO. 99/9052EE hereby declare that this project is an original design, solely constructed under the supervision of Engineer Abraham Usman. All references from both published and unpublished works have been clearly stated and acknowledged.

NOVEMBER, 2004

DEDICATION

I dedicate this project first to Elohim, my Faithful Father. You made my sojourn here a graceful one. Thank you my master, my Father and my friend. I also dedicate it to late Dr. P O Adegible; I know we didn't loose you when the Lord took you from us because you are better off in his bosom. Though a star was dimmed the day you left, for your sake we will keep shinning; Rest well sir.

ACKNOWLEDGEMENT

. I thank God for His grace over me. I'm simply a product of Your mercy. Father I am very grateful. To my parents, I love you two and; do I owe you? I sincerely acknowledge my very gentle supervisor: Engineer Abraham Usman is a very unique and wonderful man. At some point, he practically took up the responsibility of sorting for relevant materials for me. He was gentle and calm even when he had to correct or rebuke. Sir, I am very grateful, the Lord bless you.

I also acknowledge all the lecturers in the department. I will be taking a part of you anywhere I go. Thank you all; and just to let you know, your rewards will begin here.

Now to the people that made every moment of my stay here worth it, my friends. Samuel, Harold, Chehor, Damola, Bandi, Imade, Uche, Victor, my 'press family'..... I can't mention all your names, but I do love you all, and surely we'll meet again.

ABSTRACT

This project is a completely digital design whose function is to count the number of items passing on a conveyor belt. It uses two sets of counters, designed to count in the Preset mode and the normal Count mode.

The counters in the Preset mode are used to set beforehand, the number of items to be counted. The input to circuit is via an optical sensor, designed with an infra-red emitting diode and an infra-red detector. The optical sensors, sends out a signal that activates the counters in the count mode and increment their value each time the infra-red signal is interrupted.

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CHAPTER ONE

1.0 INTRODUCTION

In most industries, goods are usually produced en masse and later packaged into units or reduced into smaller items that could be easily quantified by counting. The results 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 counters are a 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 to see why productivity has decreased. For an existing company, industrial counters could be implemented for a strategy using continuous improvement. This will help show when different workstations have reached their goals.

Generally, counters are devices which store and display the number of times a particular event has occurred when needed, often relative to a clock. They are instruments for detecting, totalizing and indicating a sequence of events. They may be Mechanical, Electro-mechanical or Electronic devices.

Electronic counters are completely electronic units which keep track of the number of input signals or pulses. They have a variety of features and could be single or multifunctional units. Electronic counting functions include, mathematical operations, control functions, batch counting, totalizing, event counting, preset or pre-determining counting, pulse counting, frequency counting etc. This project focuses on one industrial application of electronic counters, viz.: keeping track of the number of items crossing on a conveyor belt.

Electronic counters could count up, down or both ways. They are implemented using register type circuits, such as the flip-flop, connected so that they toggle when the pulses to be counted are applied to the clock input. Counting is done in binary code, the 'high' and 'low' states representing the bits '1' and '0' respectively.

Electronic counters are grouped into two main categories:

ASYNCHRONOUS (RIPPLE) COUNTERS and SYNCHRONOUS COUNTERS

The term asynchronous refers to events that do not have a fixed time relationship with each other and so do not occur at the same time. So in an asynchronous counter, the flip-flops within the counter do not change state at exactly the same time because they do not have a common clock pulse. The first flip-flop is clocked by an external clock pulse then each successive flip-flop is clocked by the output of the preceding flip-flop.

Synchronous counters also use flip-flops, either the D- type or the J-K type, but in there case, each stage is clocked simultaneously by a common clock signal.

1.1 LITERATURE REVIEW

The first counting aids were probably counting stones, used to deal with the management of herds of animals and stored grains. A counting stone is a small stone that represents some particular quantity of something, for instance, one goat or one basket of wheat. By using different kinds of stones to represent different quantities, you could produce a simple physical model of the quantity of some material. [7]

Many fields of industry and commerce now use counting devices of some sort. Counting devices and their applications have evolved over the years. In Britain for instance, metering units are used to fill up beer glasses to the exact measure. The most familiar type of counting device is probably the distance recorder (odometer) of an automobile, which is a simple type of mechanical counter. [5]

The same device is used in the hand held tally used for example, to keep track of the number of people passing a given point such as a station exit.

In 1644, Blasé Pascal designed the Pascaline calculator at the age of 20, to aid his father in his job as tax collector. Mechanical gears, operated by manually turned wheels manipulated numbers up to eight digits in addition and subtraction calculations. However, in the course of calculations requiring the advance of several digits, the clockwork components, tended to break or jam. [5]

The Electromechanical counter was an improvement on the mechanical counter. This was achieved by simply adding a solenoid, to produce back-and-forth movement. Hence, provide a means of counting electrical pulses. Tachometers and rev counters for racing or passenger cars are typical examples. These counters give a reading of the number of revolutions the engine is making and are useful for engine tuning, indicating peak revs and serve as aid to efficient driving.

The 1890 census of the U.S population was processed in the record time of two and half years (the previous census had taken seven and half years to process), thanks to the use of a punched card system invented by Herman Hollerith. The replies were all entered on cards which fitted into an electromagnetic apparatus. Holes in the cards caused an electrical circuit to be computed when coming into contact with the brushes, and a calculator counted the signals.[5]

Electronic computing on the grand scale was introduced in 1946 in the form of the Electronic Numerical Integrator and Calculator (ENIAC), devised by the University of Pennsylvania. This forerunner of electronic computing weighed over 30 tons, was 100 m in length, and occupied about 278 sq. m of space.[5]

Due to their characteristics, some of which include, high speed, low cost, compactness, low power consumption, and lack of need for regular maintenance, electronic counters can perform a lot more tasks than their mechanical and electromechanical counterparts. They can be used to count ignition pulses in an engine (to produce an electronic tachometer), vibrations of a crystal (to produce an lectronic wrist watch) and oscillations of a radio signal (to produce a digitally tuned receiver). Whatever the origin of the phenomenon to be counted, it must be presented at the input to the ounter as a series of voltage pulses, called source pulses. They are implemented using integrated circuits.

CHAPTER TWO

2.0 SYSTEM DESIGN AND ANALYSIS

Due to the complexity of the design, it is broken down into modules to ease analysis. The different modules and their interconnections are represented in the block diagram in fig. 1 below:

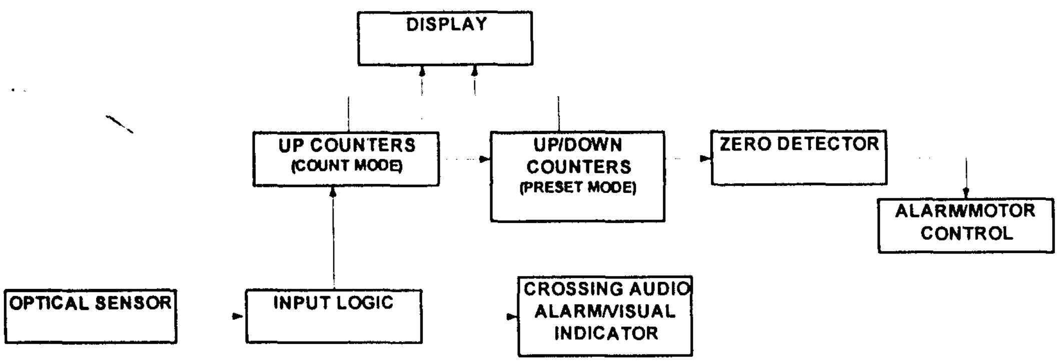


FIG. 1 BLOCK DIAGRAM

2.1 OPTICAL SENSOR

The unit is made up of the infrared source and detector. The infrared source is just an infrared emitting diode but with a great percentage of its energy given up as heat. It is made from Gallium Arsenide and has a forward bias voltage of 2.7V specified by the manufacturers. It is connected in series to a 120Ω current limiting resistor.

The infrared signal was not modulated because the distance between the source and the detector is relatively short and also for the fact that the circuit was not meant for security purposes.

The infra-red detector is also a two terminal junction device, but operates in the reverse bias mode.

The number of minority carriers depends on the intensity of light or heat radiation incident on the P-N junction. For a given reverse voltage, the reverse saturation current increases with increase in the illumination of the junction. The reverse saturation current is in the range of nanoamperes.

In a nutshell, when the infrared signal links with the detector, it acts as a low resistance device. While when the signal is interrupted, it acts as an open circuit or a high resistance device.

A transistor, designed as a switch is connected to the infra-red detector. When the infra-red signal links with the IR detector, the transistor goes well into saturation: i.e. $V_{ce} < 0$. This places both the SET pin of the S-R flip flop and the RESET pin of the input oscillator at logic '0'. When the IR signal is interrupted, the transistor goes into Cut-Off: $V_{ce} = V_{cc}$. The SET and RESET pins of the input S-R flip flop and oscillator respectively are placed at logic '1'.

The specified absolute maximum rating of the base current I_b of the transistor Q_1, 2SC944 (NPN) is 20mA. From the design, I_b is chosen to be within the range 7-10mA. This is safe enough as this same current also flows through the IR detector. The value of the resistor R1 was obtained as: –

From $$I_b = \frac{V_{cc} - (V_D + V_{be})}{R_1} \Rightarrow \frac{9 - (0.6 + 0.6)}{R} \leq 10mA$$

$$\therefore R_1 \geq \frac{7.8}{10 \times 10^3} \qquad \therefore R_1 \geq 780\Omega$$

A 1 KΩ resistor was used as R_1

A 33 KΩ resistor is used for R_2 so that the transistor goes well into saturation ($V_{ce} < 0$), when biased. See Figure 2.

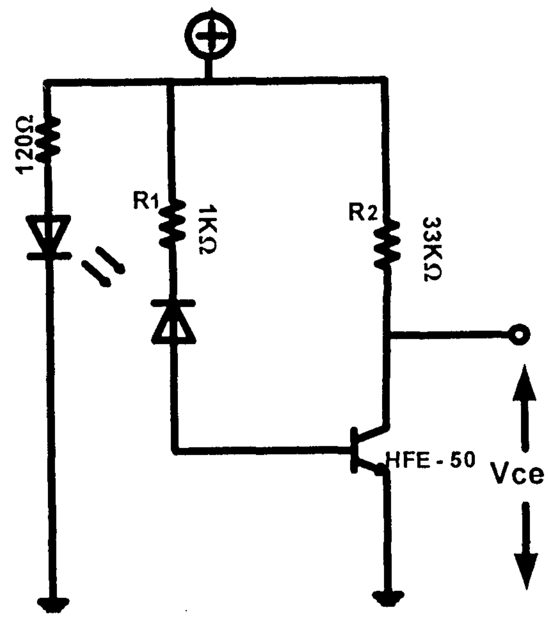


FIG. 2 OPTICAL SENSOR

2.2 INPUT LOGIC

This unit provides the timing and reset functions for this circuit. A cascade of the 4060B and the 4013B ICs are used to actualize this. The output from the transistor, is connected to the enable input of the 4060B and the SET input of the 4013B ICs. The 4013B IC is configured as an S-R flip-flop by connecting both its clock (CK) and data (D) inputs to ground. The CMOS 4060B is a 14-stage binary ripple counter with an on-chip oscillator buffer. It can function either as an RC-oscillator or a crystal oscillator, depending on how it is configured. It has a reset function on the chip that places all the outputs into their zero state and disables the oscillator. The reset is on pin 12 and is enabled on active low. Its function is to provide the low frequency signal, used to reset the S- R flip flop at intervals. Its output frequency is obtained from the formula: $F_o = \frac{1}{2.3 \times R_2 C_o}$ Where, $R_1 \geq 2R_2$ This frequency is divided through 10 stages given by: $\left(F_o/2^1 \ldots\ldots\ldots\ldots\ldots\ldots \frac{F_o}{2^{10}}\right)$ corresponding to output

the stages, $(Q_o \ldots\ldots\ldots\ldots\ldots\ldots Q_{10})$

When the IR signal links with the IR detector, the 4060 IC is enabled and its output from pin-13 resets the S-R flip-flop i.e. making $Q = 0$ and $\overline{Q} = 1$. When the IR signal is interrupted, the 4060B

IC is disabled while the SET and RESET inputs to the S-R flip-flop change from logic '0' to logic

'1' and from logic '1' to logic '0' respectively. This sets the S-R flip-flop i.e. making $Q = 1$ and $\overline{Q} = 0$. At this instance, the signal **W**, now also at logic '1', enables the 4518B ICs (up counters).

While, the '0' logic at $\overline{Q}$, completes the circuit of the LED and switches it on. The count buzzer is also triggered to beep for the duration that **W** remains at logic '1'. Once link to the IR signal is restored, the 4060B is again enabled, while the 4013B, retains its previous state of, $Q = 1$ and $\overline{Q} = 0$ for an interval of time, about 4 seconds. After which it is reset by the output from pin-13 of the 4060B IC. In order to obtain the required reset time of 4 seconds. Within this interval, it is assumed that an item must have completely crossed the IR signal. The 4060B is configured to generate a low output frequency of about 140Hz.This is so that ne of the output stages would have the required frequency of $\frac{1}{4}$ Hz.

A 0.1 μF capacitor was used and the value of the resistor was calculated thus:

$$F_o = \frac{1}{2.3 \times R_2 C_o} \qquad 140 = \frac{1}{2.3 \times R_2 \times 0.1 \times 10^{-6}} \qquad \Rightarrow R_2 = 31055.90\Omega$$

A $33K\Omega$ resistor was used in the actual construction.

The exact frequency division stage and output pin was obtained from the formula:

$$Q_x = \frac{F_0}{2^x} = \frac{1}{4}\,Hz$$ Where x, is the number of divisions.

$\therefore 2^x = 140 \times 4 \quad \Rightarrow \quad x \approx 9$ Thus the frequency division stage Q_9 which has its output at pin-13, is used to reset the S-R flip flop every 4seconds.

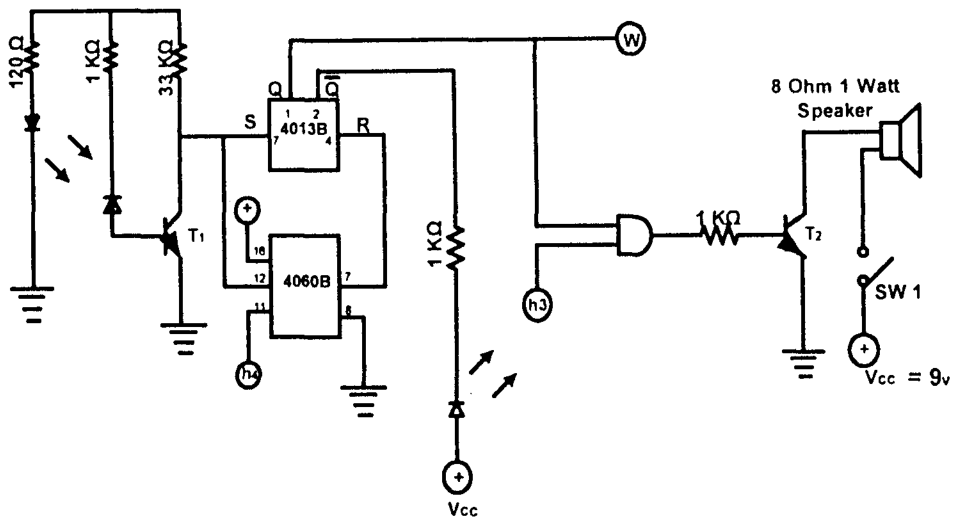


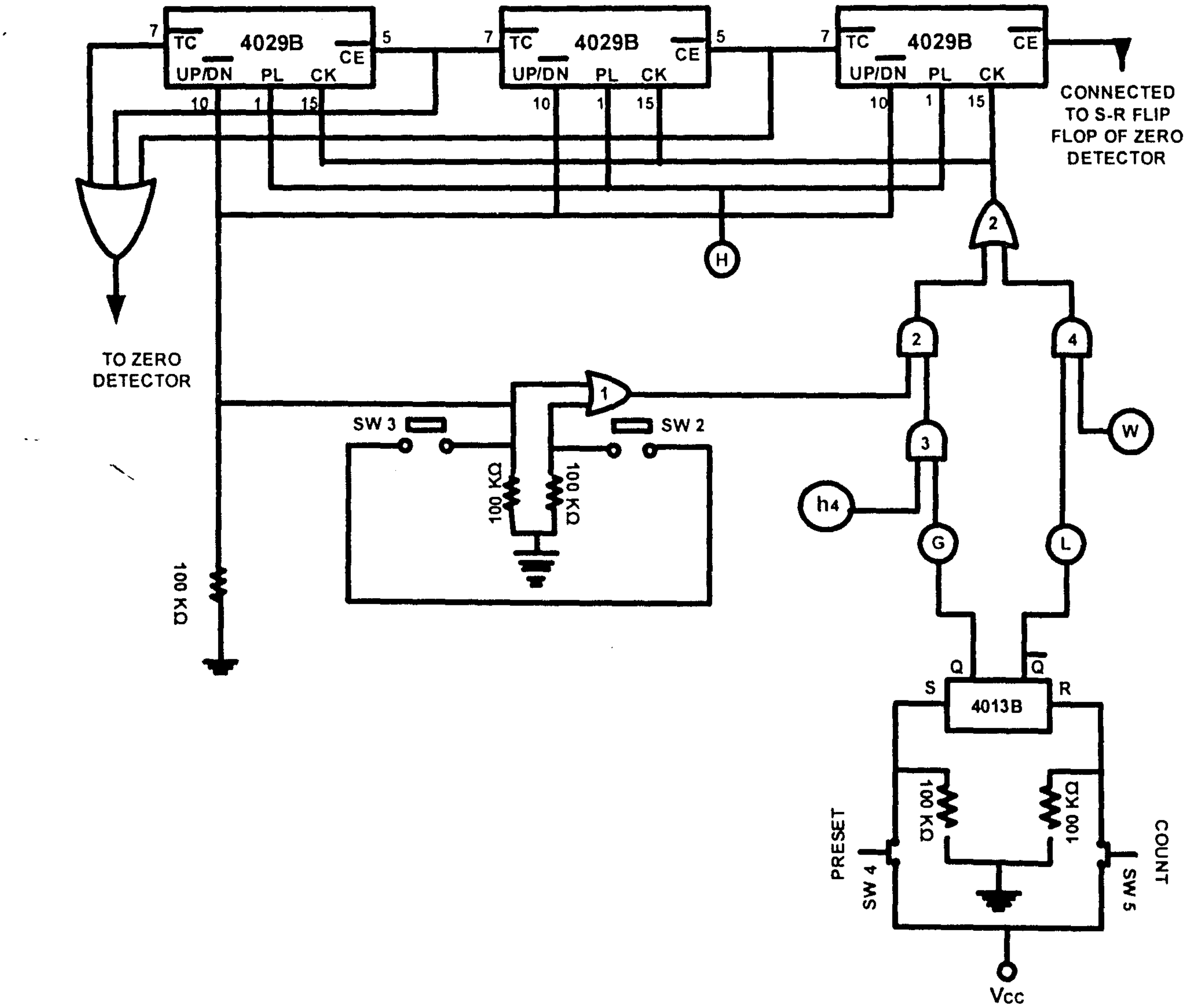
FIG. 3 INPUT UNIT

2.3 PRESET MODE

This is the mode in which the desired number of items to be counted are programmed into the counters before they start cutting across the infrared sensor. A cascade of three CMOS 4029B ICs are used in the design of this unit. The CMOS 4029B IC is a synchronous edge-triggered Up/Down 4-bit binary/BCD decade counter with a clock input (CP), an 'active low' count enable input $(\overline{CE})$, an Up/Down control input $\left(UP/\overline{DN}\right)$, a Binary/Decade control input (BIN/DEC), an overriding asynchronous 'active high' parallel load input (PL), four parallel data inputs $(P_0 to P_3)$, four parallel buffered outputs $(O_0 to O_3)$ and an 'active low' terminal count output $(\overline{TC})$. Data on $(P_0 to P_3)$, are asynchronously loaded into the counter while (PL) is 'high', independent of (CP).

The counter is advanced one count on the 'low' to 'high' transition of (CP) when $(\overline{CE})$ and (PL) are 'low'. The $(\overline{TC})$ signal is normally 'high' and goes 'low' when the counter reaches its maximum count in the Up mode, or the minimum count in the Down mode, provided $(\overline{CE})$ is 'low'. The counters are cascaded in such way that the $(\overline{TC})$ of a preceding counter, enables the Clock of the one following it.

This mode is activated by switch 4. When pressed the clock pulse to the counters passes through a selector, which is an OR-AND gate configuration to the pin-15 (CP), of the first counter. Simultaneously, the parallel buffered outputs $(O_0 to O_3)$ are cleared. Switches 2 and 3 are used to enable Up and Down count respectively by making pin-10 either '1' or '0'. Pin-10 is also connected to ground through a 100KΩ resistor so that the counters count Down normally, when neither switch is pressed. **(See figure 4)**. The frequency of the signal h_4 (refer to section 3.0) determines the speed at which they count.



2.4 NORMAL COUNT MODE

The function of this unit is to advance a set of UP counters each time an item cuts across the infrared signal. It is designed using a cascade of three CMOS 4518B ICs. The CMOS 4518B is a dual BCD counter. It consists of two, identical, independent and internally synchronous 40-stage counters. The counter stages are D-type flip-flops, with interchangeable clock and enable lines for incrementing on the positive-going or negative going transitions as required when cascading multiple stages. Each counter can be cleared by making the reset high.

These set of counters are interconnected with those in the preset mode through the selector, mentioned in section 2.3. They function concurrently, such that while they increment, those in the preset mode decrement, each time the infrared signal is interrupted. Pressing switch 5 resets the S-R flip flop and thus enables the counters. **(See figure 6).** Switch 6 is used to clear the counters while the pulse (W) from the input S-R flip flop (refer to section 2.1) is used to clock the first counter.

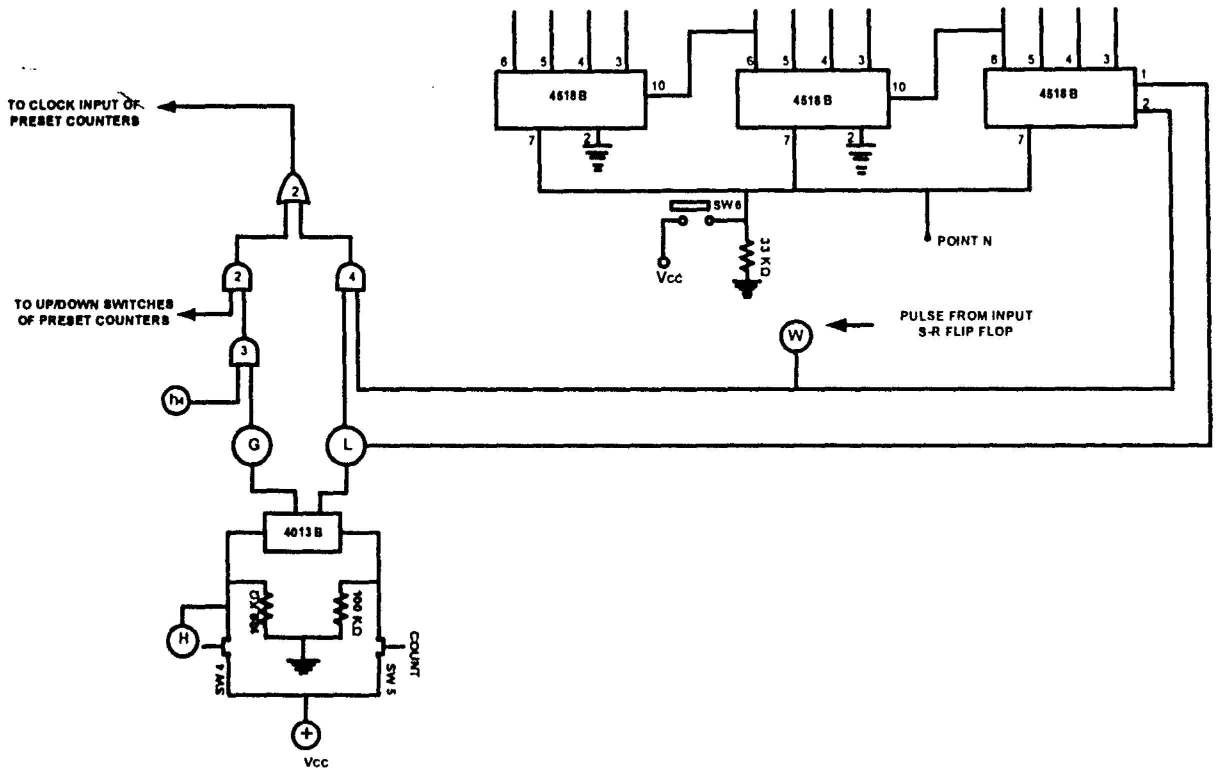


FIG. 5 COUNT MODE

2.5 DISPLAY LOGIC UNIT

This unit involves channel multiplexing technique. It consists of the actual display, made from three 7 - Segment display units, a decoder and a stepper from CMOS ICs, 4511B and 4017B respectively.

The CMOS 4511B IC is a BCD to 7-segment larch/driver with four address inputs $(D_A to D_D)$, an active LOW latch enable input $(\overline{EL})$, an active LOW ripple blanking input $(\overline{BI})$, and an active LOW lamp test input $(\overline{LT})$, seven active HIGH n-p-n transistor segment outputs $(O_a to O_g)$. When $(\overline{EL})$ is LOW, the state of the segment outputs $(O_a to O_g)$is determined by the data on$(D_A to D_D)$. When $(\overline{LT})$ goes HIGH, the last data present on DA to DD are stored in the latches and the segment outputs remain stable. When $(\overline{LT})$ is LOW, all the segment outputs are HIGH independent of all other input conditions. With $(\overline{LT})$ HIGH, a LOW on $(\overline{BI})$ force all segment outputs LOW. The inputs $(\overline{LT})$ and $(\overline{BI})$ do not affect the latch circuit.

The CMOS 4017B is a 5-stage Johnson counter, having 10 decoded outputs$(Q_0 to Q_9)$. Its inputs include a clock, a reset and a clock enable signal. Its outputs, go 'high' in turn, on the rising edge of successive clock pulses, provided reset R and clock enable (CE) are both 'low'. When R = 1, the counter resets to zero then Q_0 = 1 and all other outputs are 'low'. R must be returned to zero for counting to start again. The decoded outputs are normally 'low' and go 'high' only at their respective decoded time slot. Each decoded output remains 'high' for one full clock cycle. A carry-out signal completes one cycle every 10 clock input cycles. Counting stops if (CE) =1.

There are altogether, six data lines from both sets of counters and only three 7-segment display units. Channel multiplexing allows for data to be read from the three counters in either set, interchangeably unto the 7-segment displays. Switches 4 and 5 determine which set of counters pass data unto the decoder. Switch 4 selects the counters in the Count mode, while switch 5 selects those in the Preset mode.

The output from each counter is connected through a tri-state buffer to the decoder. The buffers are gotten from the CMOS IC 4503B. It contains 6 tri-state non-inverting buffers with high sink and source current capability. It has two disable controls, one controls four buffers while the second controls the other two Only three outputs of the CMOS 4017B IC are used and each is linked through an inverter to the enable input of each of the three buffers, in both sets of counters.

Multiplexing is achieved when the stepper enables the buffers one after the other and outputs the data from the corresponding counter to the display. The inverters allow for a compatible link between the stepper's output and the buffer's enabling input. This is because, the buffer is enabled on 'active low' while the stepper's outputs are 'active high'. The signal path is gated with a 2-input AND gate, so that when **G** is 'high', by pressing switch 5, buffers 1, 2 and 3 are enabled and their contents scanned one after the other by the stepper into the decoder. On the other hand, when **L** is 'high', by pressing switch 4, buffers 4,5 and 6 are enabled and their contents also scanned interchangeably by the stepper into the decoder. All the outputs of the buffers are linked to the CMOS 4511 IC decoder.

So the function of the stepper is to send only one 4-bit code to the decoder at a particular instance. The outputs of the decoder are then passed through separate inverters to ensure compatibility with the common cathode 7-segment display.

The PNP transistors drive the 7-segment displays and allow for the selection of the appropriate display that corresponds to the code at the input of the decoder. The buffers are scanned at a very fast rate, determined by the high frequency signal, h_5 from the CMOS 4060B IC used to clock the CMOS 4017B IC. This ensures that multiplexing is achieved at a very high speed, so all three seven segment displays appear to be on at the same time, while in reality they come on one after the other.

The second CMOS 4060B IC, is designed to generate a high frequency (about 140KHz) signal which when divided, will provide the desired range of frequencies to be used at different sections of the circuit.

$$F_o = \frac{1}{2.3 \times R_2 C_o}$$

The table below shows the output pins, the frequency division and the labels of the frequencies used from both input and display oscillators.

PIN NUMBER	DIVISION	FREQUENCY	LABEL
13	Q_9	$F_0/2^9$	h_1
7	Q_4	$F_0/2^4$	h_2
4	Q_6	$F_0/2^6$	h_3
6	Q_7	$F_0/2^7$	h_4
2	Q_{13}	$F_0/2^{13}$	h_5

h_1- Used to modulate the output audio alarm.

h_2- Used as the main audio frequency of the output audio alarm.

h_3- Used for the count audio alarm.

h_4- From Input oscillator, used to clock the preset counters

h_5- Used for display multiplexing.

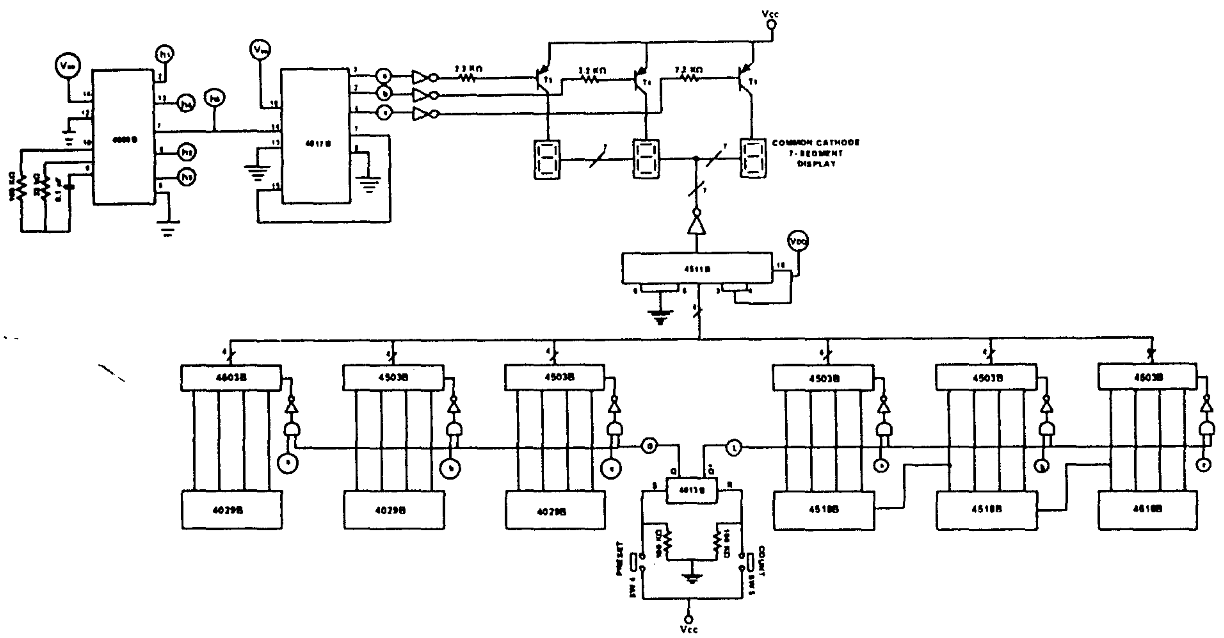


FIG. 6 DISPLAY LOGIC

2.6 ZERO DETECTOR/OUTPUT ALARM/MOTOR CONTROL

This unit functions in the count mode though; it is configured with the preset counters. Recall that three counters have counted down to zero. (The signal J is the $\overline{Q}$ output of the S-R flip flop is connected to the preset counters, count down during the normal count mode. So, the function of the Zero detector is to signal when all three preset counters have counted down to zero. Pin-7 (carry-out) of all three counters is fed through the three input OR gate 4. The output of this pin will be at logic '0' when the value on the counters equals zero. The output of the OR gate will then be at logic '0' zero if and only if all $(\overline{CE})$ of the first preset counter and will disable it when this occurs). This output is inverted by NOT gate 1 and used to reset the S-R flip-flop. The Q output of the S-R flip-flop, now at logic '0' is fed to the three input OR gate 3 and passes the signals, h_1 and h_2 from the oscillator. The mixture of these two signals $(h_1 + h_2)$ sets the tone of the alarm. The supply to the motor is also cut-off since it is fed from the Q output of the S-R flip-flop.

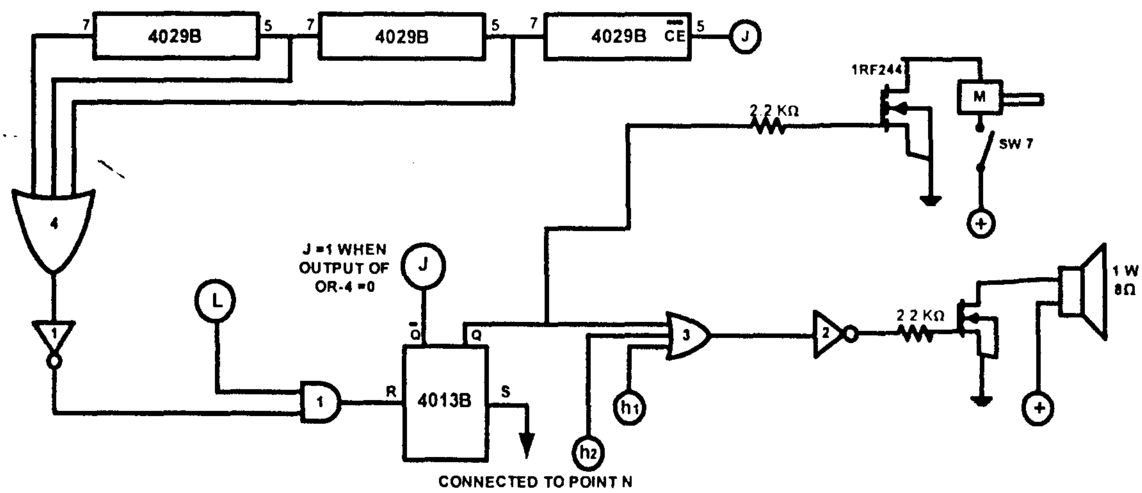
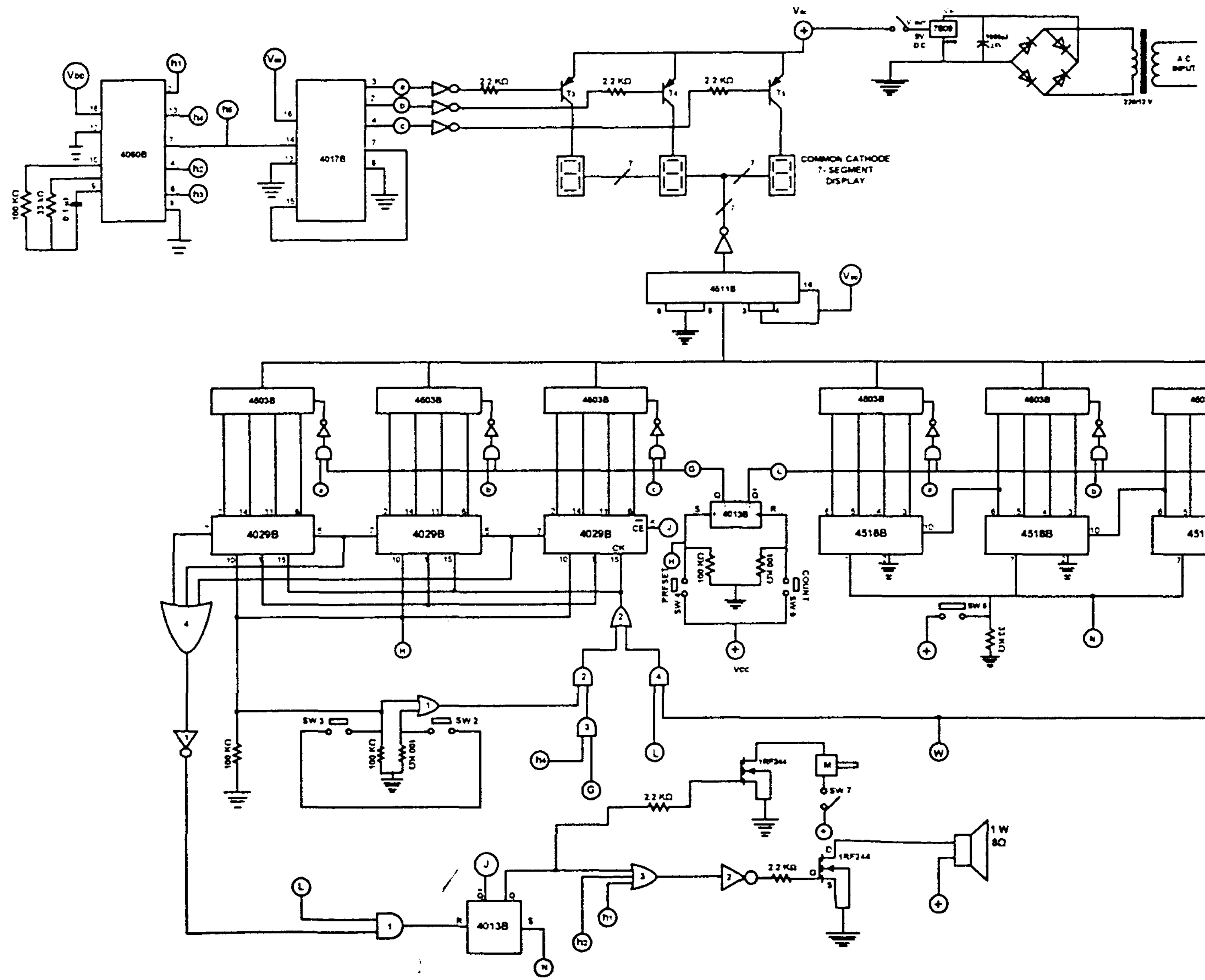


FIG. 7 ZERO DETECTOR



4060B
4017B
COMMON CATHODE
7- SEGMENT
DISPLAY
4511B
4603B
4029B
4518B
4013B
PRESET
COUNT
VCC
A C
INPUT
7808
1W
8Ω

CHAPTER THREE

3.0 CONSTRUCTION

In order to reduce complexity and effect smooth construction, the design was broken down into modules and a prototype of the entire design was first built and tested on 2 bread boards. The modules were constructed separately before they were interconnected to make up the whole design. They include; Optical Sensor, Input Logic, Preset Counters, Normal Counters, Zero Detector/ Motor Control and Display logic.

After it was certified that the design was functional, a plan on how the components would be physically arranged on the Vero board was drawn up.

Based on this plan, a layout of the various components that constitute each module and there interconnections was mapped out on plain paper before they were physically transferred to the board.

The major challenge was how to strike a balance between compactness and proper spacing to allow for ease of maintenance.

A number of factors were put into consideration while planning for the component layout, they are:

- The total number of ICs in the circuit
- The pin assignments of the ICs and the interconnections between them
- The interconnections between the various components in the circuit.

3.1 TEST AND INSPECTION

Having completed the construction, a series of inspections and tests were carefully carried out as follows:

- Test of the continuities of all the connecting leads
- Short circuit tests between the supply rail and ground and between components.

- Test of the polarities of all polarized components
- Measurement of the voltage, current and resistance values at different points in the circuit in comparison with the design values.
- Measurement of the outputs of the various modules in comparison with the design requirements
- Careful inspection to ensure that all unused IC terminals are properly grounded

After the results of the above tests were confirmed to be satisfactory, the device was placed on full operation and carefully observed.

When power was switched on, the desired number of bottles to be counted was preset, using switches 4 and 5. With switch 3, the circuit was reverted to function in the normal count mode. It was observed that, each time a bottle crossed between the IR transmitter and the IR detector, the LED came on for about 4 seconds and the speaker beeped for the same duration of time. The 7-segment displays showed the number of bottles that had crossed the beam.

When the number of bottles that had crossed the IR signal equaled the preset value, an alarm was triggered and the motor driving the conveyor was automatically switched off.

3.2 TOOLS USED IN CONSTRUCTION

The tools used in the construction and testing of the device include:

- 2 bread boards and insulated copper wires, used to build the prototype of the circuit and interconnect components.
- A 40 watt soldering iron and thinned lead, used to solder components to the Vero board.
- A digital meter, used to carry out measurements and tests.
- A suction tube, used to suck out excess lead from the board to avoid short circuit and ensure a clean job.

3.3 PACKAGING

The device was neatly packaged in a rectangular wooden box. Provision was made for the outlets of the 7-segment displays, the LED and the buzzer. Also, holes were bored as outlet to the speaker which was also embedded within the casing. A model of a small conveyor belt was made with the IR transmitter and detector properly aligned to each other and firmly attached to the edge of the rail on the conveyor.

CHAPTER 4

4.0 CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION

Based on the satisfactory results obtained from testing this device, it can be concluded that simple and cost effective automatic devices can be fully implemented for such activities as counting both in large and small scale. This goes to show the versatility of digital electronics. With digital electronics, it will be possible to fully realize self directing devices which will be able to follow a specific set of defined operations without human intervention. Thus, saving both time and energy, and yet very efficient.

4.2 RECOMMENDATION

For future improvement to this project, I recommend that a module to aid long distance operation of the device be incorporated. For example a remote control. Also, another timer unit and microprocessor could be incorporated, so that the preset value could be easily programmed and erased at will. With the extra timer, the conveyor could be programmed to start again after an interval of time required without the intervention of the operating personnel.

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SECOND EDITION

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