

DESIGN AND CONSTRUCTION
OF A DIGITAL
FREQUENCY METER

BY

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2000/9924EE

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OCTOBER, 2006

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FREQUENCY METER**

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**SULEIMAN MOSHOOD OLAWALE
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**IN PARTIARL FULFILMENT OF THE
REQUIREMNTS FOR THE AWARD OF A
BACHELOR OF ENGINNERING DEGREE
(B.ENG) IN ELECTRICAL/COMPUTER
ENGINNERING.**

OCTOBER, 2006

DEDICATION

This project is dedicated to the all might Allah the beneficent the merciful, the uncaused cause of all beings and to my parent who always stand by me throughout my academic career.

DECLARATION

I hereby declare that the project work is my original work and effort under the supervision of Mr. J.A. Abolarinwa of the department of Electrical and Computer Engineering, Federal University of Technology Minna. And to the best of my knowledge has never been submitted elsewhere for the award of Diploma or Degree certificate.

Suleiman Moshood Olawale

(Student)

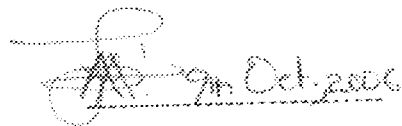

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Signature and Date.

CERTIFICATION

This is to certify that the project titled: Design and Construction of Digital Frequency Meter (0 – 100KHz) was carried out by Suleiman. M. Olawale under the supervision of Mr. J.A Abolarinwa and submitted to the Department of Electrical and Computer Engineering, Federal University of Technology, Minna Niger State in Partial fulfillment for the requirement for the award of bachelor of Engineering (B. Eng) in electrical and Computer Engineering field.

Mr. J. A Abolarinwa
(Project Supervisor)



A handwritten signature in black ink is written over a horizontal dashed line. To the right of the signature, the date "9th Oct 2006" is written in the same ink.

Signature and Date

ENGR. M. D Abdullahi
(Head of Department)

Signature and Date

(External Examiner)

Signature and Date

ACKNOWLEDGEMENT

I would like to thank God almighty for his grace, favour and faithfulness. My sincere gratitude goes to my supervisor Mr. J.A. Abolarinwa for his intelligent and valuable suggestions provided throughout the period of this work. I am highly grateful to all members of staff of the department for the numerous ways in which they have been of help to me during the course of my studies especially my course advisor through my stay in F.U.T. in the name of Mr. J. B. Kolo you as been of great help to me during the course of my studies. Not forgetting Mallam Umar Abubakar

I will remain forever grateful to my parents and brothers the Suleiman's in the person of Yinka, Tunde, Gbola, Moyo, Seun, Usman and Rotimi for their unreserved support which contributed greatly to my success.

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ABSTRACT

This project presents the design and construction of a digital frequency meter that can be used to measure the frequency of periodic signals. The working of this device is based on the principle of sampling of signal. It can measure frequencies from 0Hz to 100 KHz. The features included are a crystal oscillator, various time base settings and a frequency or period select switch.

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CHAPTER 1

1.1 INTRODUCTION

Science and technology are so interwoven with measurements that they are totally inseparable from it. Scientific facts need precise measurements for their establishment and the development of science and technology to generate new instruments in a continuous cycle.

Although simple quantities have been measured from ancient time, precise measurement is only a few years old and many of the quantities measured today were not even known to exist. Even so fundamental a dimension as time was measured extremely crudely with sand water clocks until Galileo's observation on the pendulum suggested replacing them with mechanisms with resonant systems in which cycles are counted. The same principle is used for clocks today with better accuracy as better resonant systems were discovered.

The ability to measure time using resonant system is due to the fact that a time interval is simply an inverse of the system's frequency. The frequency of a repetitive signal is defined as the number of cycles per unit time. Time interval and frequency are so interdependent that measuring one means measuring the other also. Any standard or definition for one can be adopted to the other, e.g., the unit of frequency Hertz (Hz), is a derived unit equivalent to one event per second.

Most physical system works with signals which are within a certain frequency range, e.g., the sound produced in speech contain frequencies which lie within a frequency band of 100 – 10000Hz, radar systems work with a frequency band of 30 –

300MHz, etc. systems that carry information from place to place, e.g., radios, television, etc are especially on proper understanding processing of the range of frequencies involved.

The way different systems respond to different values of frequencies differ according to the physical condition and the design. E.g., in long distance point to point communication, very low frequencies are absorbed more during the day than the night time. The system might also be selective about the range of frequencies it passes through, e.g., filters. All waveforms are composed of an infinite number of waveforms of an infinite frequency range consisting of the fundamental harmonics. Thus the output might be different from the input unless the system was designed properly and can therefore respond correctly to the appropriate range of frequencies

The requirements demanded of any system depend on the type of information it processes, but one of the typical requirements is that it is intelligible after all the processing, and this means that for any waveform sufficient frequency should be retained to represent it properly. It is therefore necessary to have an understanding of the range of frequencies involved in a system, the system frequency responds and how to measure these frequencies accurately.

Frequency meters are designed to measure the number of wave cycle in a second. It is mostly suitable for normal and smooth sine wave or pulse. The reason is basically for true measurement. Frequency meters function with the S.I. unit of Hertz. One Hertz is defined as the reciprocal of a second (period). Frequency counter operates

on the principle of gating the input frequency into the counter for a predetermined time.

[7]

There are different types of frequency measuring device. In its digital type, measuring accuracy and ease in operation are quite encouraging. It is mainly used in electronic laboratories. Its operation goes along with other devices such as oscilloscope and frequency generator. One of its simplest applications is the measurement of the frequency output of an audio frequency (A.F) oscillator. More advanced frequency meters display input in giga-Hertz.

The first set of known frequency meter known were analogue such as the vibrating-reed frequency meter, which depends on its indication on mechanical resonance of thin steel reeds arranged along side and close to an electromagnet. The working principle this type of frequency meter is the alteration of magnetism when the supply of the frequency to be measured is connected across it. Another one is the moving iron frequency meter in this case the action of the meter depends on the variation in current drawn by two parallel circuits. One inductive and the other non-inductive when frequency changes also is the electrodynamic frequency meter.

There are lots of digital frequency meter in circulation today, of which most involve the use of the 555 timer which does not guarantee much accuracy when used to measure frequency due to its power properties.

1.2 AIMS AND OBJECTIVE OF THE PROJECT

The project is aimed at the design and construction of a digital frequency meter. Its main purpose is to measure frequency within the range 0 – 100 KHz and digitally displayed.

1.3 METHODOLOGY

The design can be grouped into four main parts. The cornerstone of the device is the crystal oscillator. It is the most significant part of the circuit because it deals with timing. A crystal oscillator is attributed to an appreciable precession frequency or timing output. The driving component of the crystal is the 4060B 14-stage oscillator/driver. It works with a 32768Hz crystal and with internal divisions a stable 1Hz or 1 second signal is accomplished. This signal is used for sampling the input signal or pulse. It is quite evident that the common 555 timer integrated circuit can not be compared with the leading oscillator. This is due to the fact that 555 timer is a RC oscillator. It does not hold in to a stable output. "555" timer for a frequency meter means error of an unacceptable degree. Also, the 4060B is a complementary metallic oxide semiconductor (CMOS) integrated circuit. It does not consume too much power as most oscillator, such as 555 timer do. It is quite compact and it works with wide range voltage supply. Therefore, it possesses little record of error due to power supply instability. Indeed, the crystal oscillator is a good choice due to the time importance of a frequency meter.

The normal meaning of the term frequency in accordance with or pulse is the number of cycle in one second [5]. So for a good frequency meter, a means must be provided to sample the measured input signal every one second. Although the timing is provided by the crystal oscillator, a logic control unit is required for basic operation such as sample latch and reset. These duties are carried around in circuit one after the other. For more clarity, the logic control unit harmonises the altogether parts that made up the device. It is made of two logic gates; namely AND and NOT. The other remaining parts including the crystal oscillator work along with the commands of the logic control unit for a useful result.

The other two parts are the counter and display units. An up binary coded decimal (BCD) counter is incorporated into the design to count the number of cycles or useful edges in a one second spaced input signal in the frequency meter. As earlier explained, the oscillator provides the one second timing and the logic control unit helps to process the display of the input signal. The logic control unit holds the result of the counting in a latch and then clear or reset the counter back to zero count every one second. The operation is in one second cycle. There is always refreshment of result.

This is the basic concept involved in most frequency meter but it is not complete with the display unit. This unit converts the code from the latch/counter into visual format. The resulting information is displayed on a 7-segment display panel as the frequency of the signal under measurement.

1.4 SCOPE OF THE PROJECT

The project is all about a digital frequency meter with maximum measurement of 99,999Hz. Therefore frequency outside this range hence is not compatible with the device. It operates on a crystal oscillator for timing, and not RC type. Therefore, the device is within an acceptable accuracy. The project is designed for low power consumption. All involved integrated circuit are complementary Metallic Oxide Conductor (CMOS). The integrated circuits (IC) are included in the 4000 series. The common Transistor –Transistor-Logic (TTL) 7400 series was not considered due to high power consumption and low compact logic availability. Moreover, Light Emitting Diode (LED) display is incorporated into the design. This device could be used to measure various frequency readings such as the frequency of an AC source, or in the laboratory with reference to RC experiments.

1.5 LIMITATIONS AND CONSTRAINTS

The project is attributed to a major error of +1 for every reading. But interestingly this error is constant. Therefore one is subtracted from every reading made in the device to eliminate the error.

CHAPTER 2

LITERATURE REVIEW

Frequency measurement requires a very accurate standard for comparison with the unknown. Many standards of time have been defined and as more and more accurate measurements were needed, the standards also had to become more precise. This requirement, coupled with recent complex development in electronics, has led to the use of transitions in energy states of atoms. In 1964:

"The standard to be employed is the transition between two hyperfine levels of the ground state of the cesium-133 atom and the value 9,192,631,770 hertz is assigned"

(13th General Conference on Weights and Measure, 1967 Resolution)

In a recent check of time scales kept over a period of two years, the maximum observed difference was about 100 μ s. Atomic frequency thus serves as a basis for a precise physical frequency or time scale and all other measurements are made with respect to it.

Frequency can be measured by comparison, by counting, by balancing a frequency sensitive bridge, etc. Before the coming of digital electronics, analogue means of measurement was used. Relatively few of these instruments are now used in practice.

[5]

An analogue comparison can be obtained by means of Lissajous patterns displayed on an oscilloscope. The pattern is obtained from applying the unknown and a

known frequency to the plates of the oscilloscope and the figure gives the ratio of the frequencies.

In heterodyne comparison method, the difference of the frequencies is obtained and the waveform is observed in an oscilloscope.

The vibrating reed frequency meter, which has now been restricted to laboratory uses, has a graded number of thin steel reeds which are tuned to respond to the line frequency. Though it is not easy to read, its advantage is that the indications are dependent on the fundamental frequency, not voltage and its is temperature independent.

The tuned circuit frequency meter consists of a tuned circuit which allows only the fundamental to pass through. It has a pair of coaxial fixed coils and a moving winding which produces a torque. To indicate frequency, a control is needed and this is a moving vane that aligns itself with the field of the fixed coils.

The Weston frequency meter is of the moving iron type. Two field coils mounted at right angles to each other act upon a single iron needle carried by a shaft. It also carries a pointer and a damping vane. The needle is displaced by a magnetic field from the central position, which corresponds to the normal operating frequency.

A bridge network consists of resistors and capacitors connected to the line voltage and indicate changes in frequency, which can be recorded by an auxiliary motor. This is very insensitive to changes in temperature and line voltage.

The above analogue means of measuring frequency are disadvantaged by the fact that accuracy is not usually very high and a skilled operator is needed to operate the

meters. In addition, other factors like line voltage, temperature, mechanical movement and vibration causes errors in frequency indication.

The method of digital measurement offers an ideal solution for frequency measurement. It is extremely accurate, can work over a wider range of operating conditions, can handle a larger variation in input signal and can be miniaturized in size so that more functions can be implemented.

Frequency meter is a device for measuring the number of cycle per unit of time (Customarily, a second) of a complete electromagnetic waveform. Various types of frequency meters are used. Many old designs are instruments of the deflection type, ordinarily used for measuring low frequencies but capable of being used for frequencies as high as 900 Hz. These operate by balancing two opposing forces. Changes in the frequency to be measured cause a change in this balance that can be measured by the deflection of a pointer on a scale. Deflection-type meters are of two types, electrically resonant circuits and ratio meters. An example of a simple electrically resonant circuit is a moving-coil meter. In one version, this device possesses two coils tuned to different frequencies and connected at right angles to one another in such a way that the whole element, with attached pointer, can move. Frequencies in the middle of the meter's range cause the currents in the two coils to be approximately equal and the pointer to indicate the midpoint of a scale. Changes in frequency cause an imbalance in the currents in the two coils, causing them and, in turn, the pointer to move.

Modern designs involve advanced integrated circuits in form of microcontrollers and microprocessors. Many others are computer programs or soft wares. They require

additional hard wares with the computer for compatibility modern frequency- meters respond to frequencies in gigahertz. They are mostly used in high radio frequency analysis.

CHAPTER 3

DESIGN AND SYSTEM OPERATION

3.1 THEORETICAL BACKGROUND

Frequency is the measurement of the number of times that a repeated event occurs per unit time. To calculate the frequency, one fixes a time interval, counts the number of occurrences of the event within that interval, and then divides this count by the length of the time interval. In SI units; the result is measured in hertz (Hz) after the German physicist, Heinrich Rudolf Hertz. 1 Hz means that an event repeats once per second. Other units that have been used to measure frequency include: cycles per second, revolutions per minute (rpm). An alternative method to calculate frequency is to measure the time between two consecutive occurrences of the event (the period) and then compute the frequency as the reciprocal of this time [6].

The sequence of events within the frequency counter is controlled by the time base, which must provide the timing for the following events resetting counter, opening the count, gate closing the count gate and storing the counted frequency in the latch. Accuracy of the frequency depends directly on accuracy of the time base signal hence it is derived from a crystal oscillator [7].

The project involves the digital means of measuring frequency of signals. The involved design involves four main parts.

They are:

- i) an crystal oscillator
- ii) a logic control unit
- iii) a logical counter unit
- iv) and the display

An oscillator is required for sampling the input signals of a frequency-meter. It is often necessary to generate a one-second timing control for allowing a portion of the input signal to be counted. Most old projects used the common 555 timer integrated circuit for their oscillator -input control timing. This oscillator is always in its RC configuration. Such oscillator is attributed to unstable frequency output. Therefore, any involved timings with this kind of device is always with reasonable error. A 555 timer for the heart of a frequency-meter is practically not suitable.

The project involves a CMOS 4060B integrated circuit oscillator in the crystal configuration. The device provides a reasonable timing accuracy. It is attributed to ten frequencies. The oscillator is quite unique in operation. It produces a high frequency of 32768Hz from crystal. Through internal divisions, lower frequencies are achievable. The device divides the particular fourteen times to generate an output of 2Hz. Additional external logics further reduce the frequency to 1Hz. This timing is

indeed stable with time. The involved precision is applicable for frequency measurement. The oscillator is attached to numerous merits such as low power consumption, low cost, wide voltage supply, and encouraging availability. The choice of the oscillator is mainly based on the frequency stability for minimum sampling error.

The logics control unit is incorporated into the design to coordinates the main operations of the whole circuit. The input signal or pulse is connected to the logic control unit. This logic unit directs the input into the counter unit for just for a second. It allows the corresponding results of an input sampling to be displayed.

The counter unit is designed to count the available circles of the sampled pulse. The counting result is the numerical value of the input frequency. The counters are configured in a very fast mode for reasonable response. The display is Light Emitting Diode (LED) in nature. A Light Crystal Display (LCD) could be better due to its lower power. But, the display holds more advanced configuration and technical experience.

3.2 DESIGN ANALYSIS

The design is based on complementary metallic semiconductor (CMOS) logic technology. The logic possesses numerous advantages over its transistor transistor logic (TTL) counterpart. CMOS is a widely used type of semiconductor. CMOS semiconductor uses both NMOS (negative polarity) and PMOS (positive polarity) circuits. Since only one of the circuit types is on at any given time, CMOS chips require less power than chips using just one type of transistor. This makes them particularly

attractive for use in battery-powered devices, such as portable computer. Personal computers also contain a small amount of battery-powered CMOS memory to hold the date, time and system setup parameters. The other advantages of this technology include high compatibility, wide supply voltage range, high flexibility, encouraging logic availability, high turn-out etc.

Standard discrete CMOS logic functions were originally available only in the 4000 series of logic integrated circuits. Later many functions in the 74 series (TTL integrated circuits) be can to be fabricated in CMOS, NMOS, BI CMOS or another variant [4]. The 4000 series is the general classification used to refer to the industry standard integrated circuits which implement a variety of logic function using CMOS technology.

This project is centralized on the 4000 series. All involved logic circuits are classified under this series.

3.3 CHOICE OF MATERIALS AND COMPONENTS

As earlier explained, the main parts of this project are 4000 series CMOS integrated circuit. They offer significant performance for the altogether project. The most importance is the small and limited power consumption of the circuit. It results into battery-powered capability of the device.

The involved integrated circuits are as follows:-

1. 4060B (Crystal oscillator/divider)

2. 4518B (Dual BCD up counter)
3. 4511B (7-segment decoder/latch)
4. 4081B (Quad 2-input AND gate)
5. 4069B (Hex inverter)
6. 7805 (5V regulator)

3.3.1 4060B

The 4060B is a CMOS integrated circuit (IC) which functions as both oscillator and divider. Interestingly, it produces ten frequencies at the same time. The 4060B is designed with fourteen internal dividers. They break down the main frequency from an internal oscillator. The oscillator configuration allows design of either RC or crystal oscillator circuits. Also included on the chip is a reset function which places all ten frequency outputs into the zero state and disables the oscillator. The clocking is done at negative transition which advances the counter to next status. Schmidt trigger action on the input line permits very slow input rise and fall times. As usual with CMOS integrated circuit, 4060B works at supply voltage range of 3 – 18V. All its outputs are buffered; therefore the device is protected from static charge destruction.

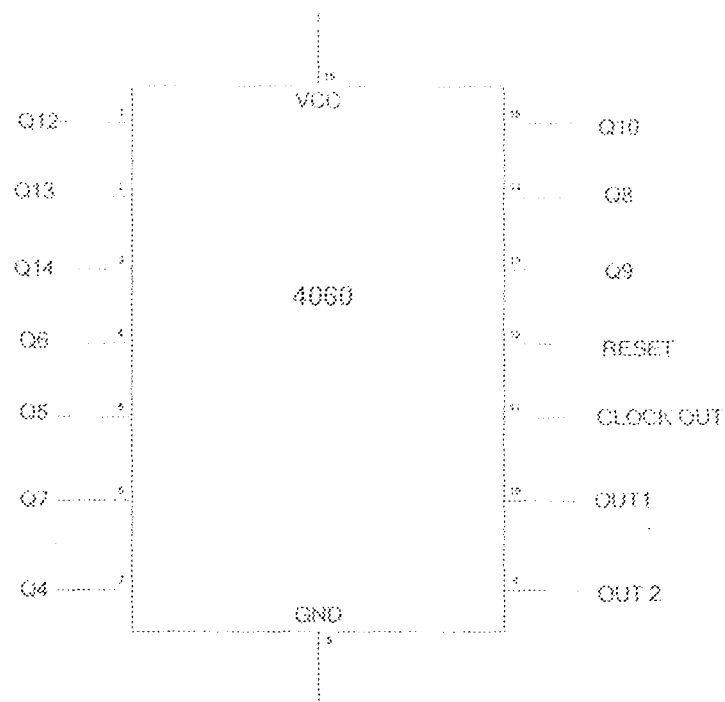
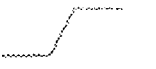
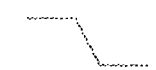


Fig. 3.1 Pin assignment of 4060b

Table 3.1 Truth table of 4060b

CLOCK	RESET	OUTPUTS/STATE
	L	NO CHANGE
	L	ADVANCE TO NEXT
X	H	ALL OUTPUT ON LOW

X => don't care

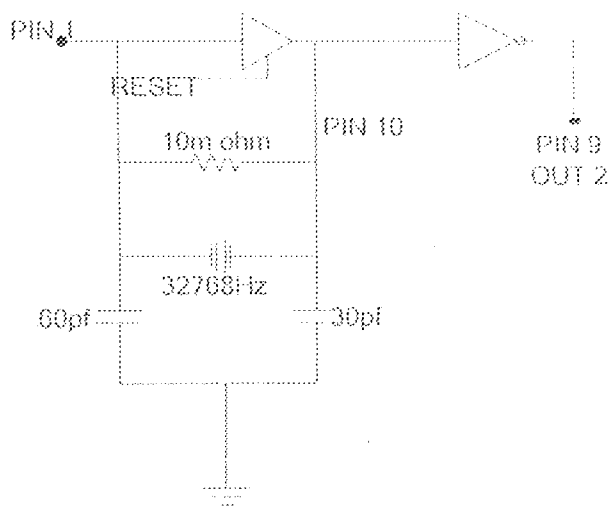


Fig. 3.2 Typical crystal oscillator circuit

The above diagram shows the crystal oscillator of 32768Hz frequency. The values of the involved components are specified by the data sheet.

The Q values of the frequency outputs are required for calculating the frequency of the respective terminal [8]. The required formula is below.

$$F_{ox} = f_n / 2^x$$

x = is the Q value

f_n = is the oscillator frequency (32768Hz in this case)

for instance, the output frequency of Pin 7 is given below

$$F_{o7} = 32768 / 2 = 20481 \text{ Hz}$$

The same formula follows the other output terminals.

3.3.2 4518B

4518B is a dual BCD up-counter. The 16-pin integratal circuit holds two identical internally synchronous 4-stage counters. The counters stages are D-type flip-flops having interchangeable clock and ENABLE liner for increment on either positive-going or negative-going transition. For single-unit operation the ENABLE input is maintained high and the counter advances on each positive-going transition of the clock. The counters are cleared by high levels in their RESET lines. The counter can be cascaded and the ripple made by connecting Q4 to the enable input of the subsequent counter while the clock input of the latter is held low. The medium speed of operation is 6MHz at 10V power supply.

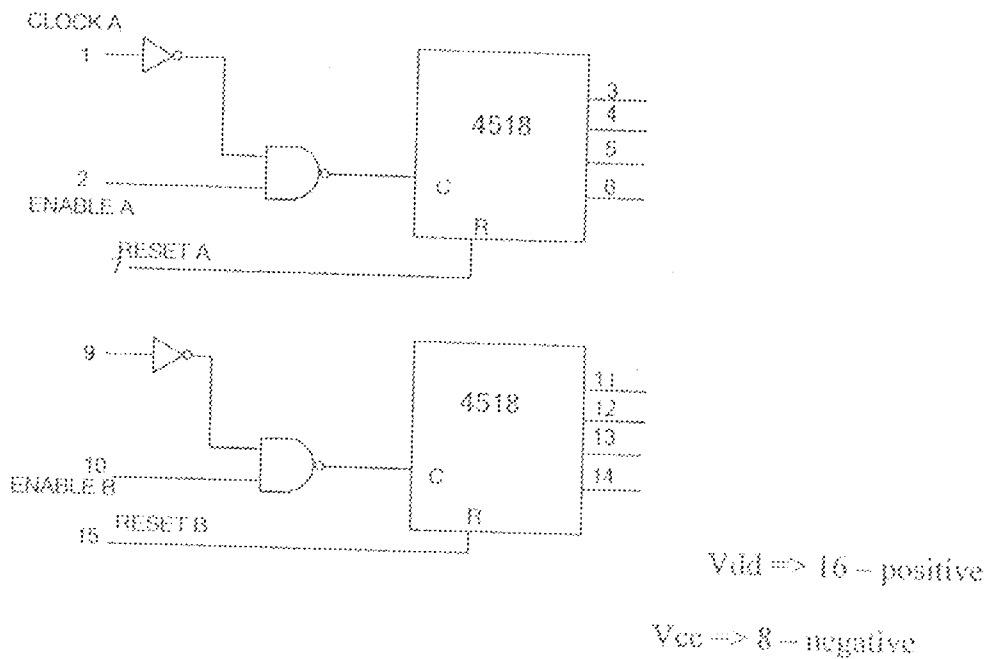
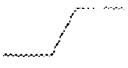

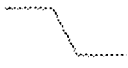
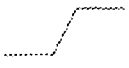
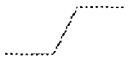
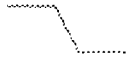


Fig. 3.3 The functional diagram of 4518B

Table 3.2 Truth table of 4518B

CLOCK	ENABLE	RESET	ACTION
	1	0	Increment counter
0		0	Increment counter
	X	0	No change
X		0	No change
	0	0	No change
1		0	No change
X	X	1	Q1 through Q4 is equal to 0

X => don't care 1 -> high state 0 => low state

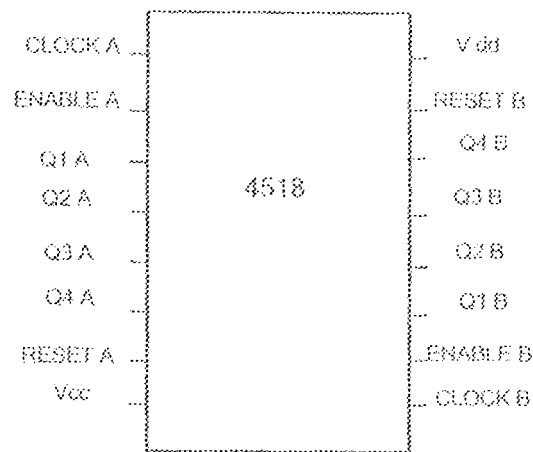


Fig. 3.4 Terminal assignment of 4518B

3.3.3 4511B

4511B is a BCD-to-7-segment latch decoder drivers constructed with CMOS logic and n-p-n bipolar transistor output devices on a single monolithic structure. The design allows direct driving of LED's and other displays. The integrated circuit possesses lamp test (LT), blanking (BD) and latch. Enable or strobe inputs are provided to test the display, shut off or intensity-modulate it and store or strobe a BCD code, respectively. Several different signals may be multiplexed and displayed when external multiplicity circuitry is used. The device is used for driving common-cathode LEO displays, multiplexing with common-cathode LED displays, driving incandescent displays and driving low-voltage fluorescent displays.

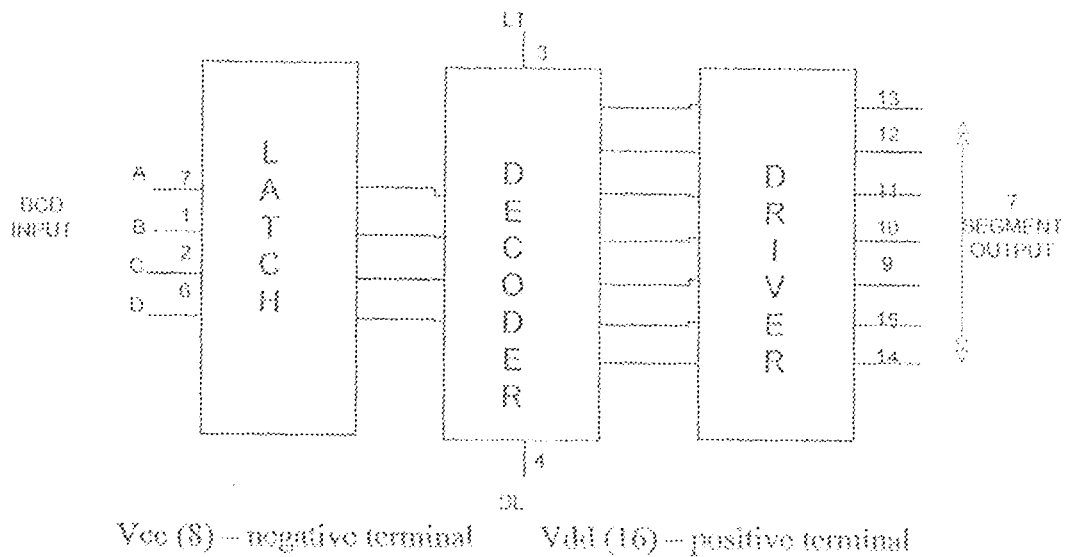


Fig. 3.5 Functional diagram of 4511B

Table 3.3. The truth table of 4511B

LE	BT	LT	D	C	B	A	a	b	c	d	e	f	g	Display
X	X	0	X	X	X	X	1	1	1	1	1	1	1	8
X	0	1	X	X	X	X	0	0	0	0	0	0	0	BLANK
0	1	1	0	0	0	0	0	1	1	1	1	1	0	0
0	1	1	0	0	0	1	0	1	1	0	0	0	0	1
0	1	1	0	0	1	0	1	1	0	1	1	0	1	2
0	1	1	0	0	1	1	1	1	1	1	0	0	1	3
0	1	1	0	1	0	0	0	1	1	0	0	1	1	4
0	1	1	0	1	0	1	1	0	1	1	0	1	1	5
0	1	1	0	1	1	0	0	0	1	1	1	1	1	6

0	1	1	0	1	1	1	1	1	1	0	0	0	0	7
0	1	1	1	0	0	0	1	1	1	1	1	1	1	8
0	1	1	1	0	0	1	1	1	1	0	0	1	1	9
0	1	1	1	0	1	0	0	0	0	0	0	0	0	BLANK
0	1	1	1	0	1	1	0	0	0	0	0	0	0	BLANK
0	1	1	1	1	0	0	0	0	0	0	0	0	0	BLANK
0	1	1	1	1	0	1	0	0	0	0	0	0	0	BLANK
0	1	1	1	1	1	0	0	0	0	0	0	0	0	BLANK
0	1	1	1	1	1	1	0	0	0	0	0	0	0	BLANK

X -> don't care

The integrated circuit is only compatible with common cathode LED display. It does not possess LCD capability.

3.3.4 4081B

4081B is a 14-pin CMOS integrated circuit. The single chip hold four 1-input AND gates.

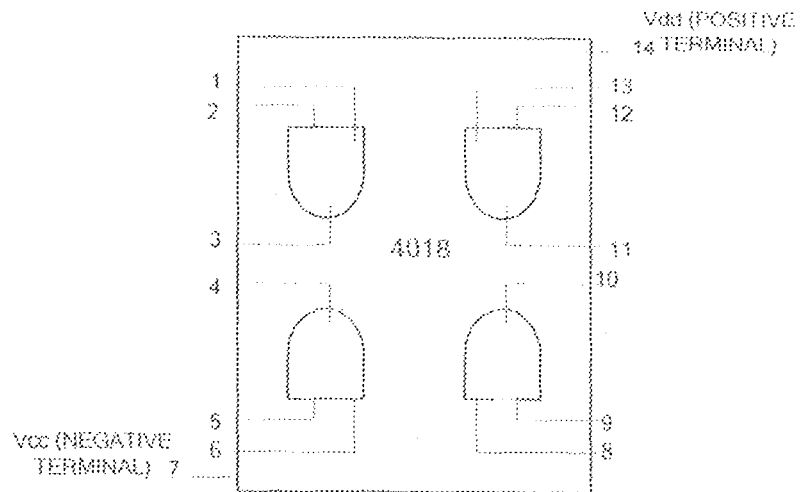


Fig. 3.6. Pin layout of 4081B

Table 3.4. Truth table of a 2-input AND gate.

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

3.3.5 4069UB

4069UB is a CMOS hex inverter integrated circuit. The single device possesses six NOT gates.

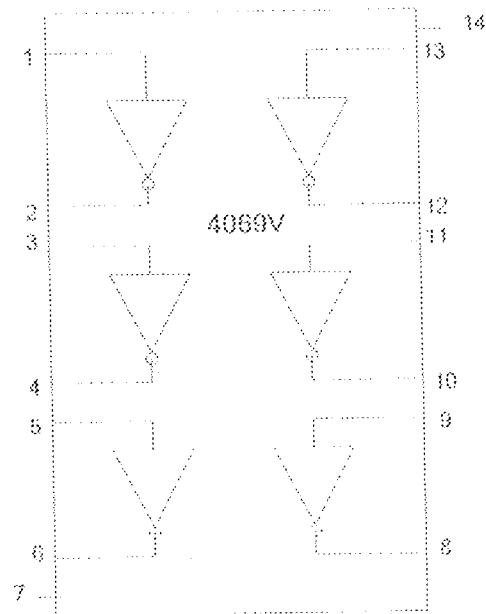


Fig. 3.7. Pin layout of 4069UB

3.3.6 7805

7805 is an IV regulator. It is designed to operate at maximum input voltage of 35V. It possesses thermal shut-down. This protects it from over-heating.

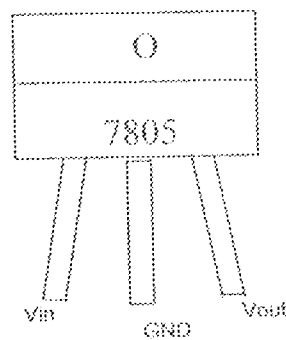


Fig. 3.8. Pin layout of 7805

The LED display type is common cathode. The dimension is 10mm x 20mm.

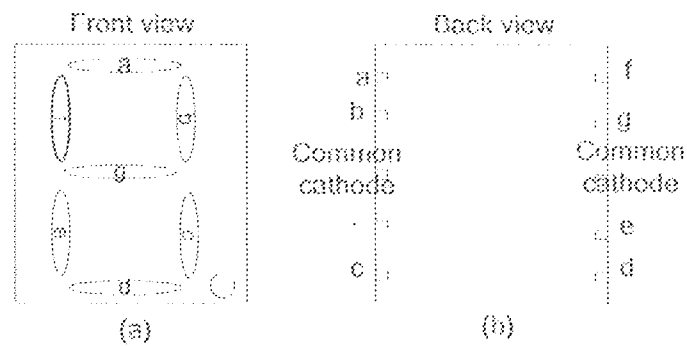


Fig. 3.9. Pin layout of the common cathode LED display

3.4 MAIN CIRCUIT DESIGN

The project can be grouped into five main parts including the power supply unit.

The units are as follows: -

- (i) Power supply unit
- (ii) Crystal oscillator/dividers
- (iii) Control logic
- (iv) Counter unit, and
- (v) Display unit

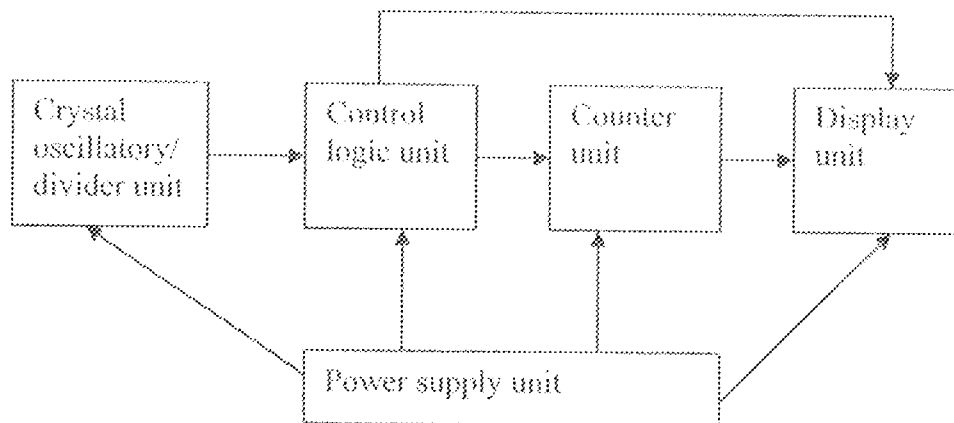


Fig. 3.10. Block diagram of the project

Each part of the block diagram works in accord with other to result into the target function.

3.4.1 Power supply unit

Due to the frequency of normal and conventional power supply units, little focus is given to this unit. It merely involves a 12V A.C. supply step-down transformer, four rectifying diodes for bridge rectifier configuration and a 5V regulator.

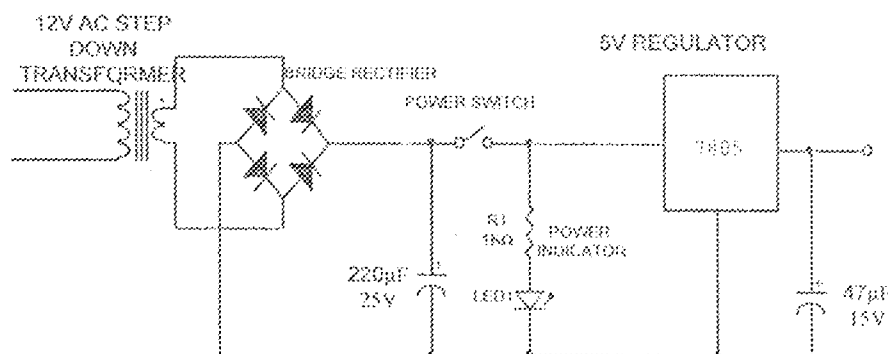


Fig. 3.11. Power circuit

The involved rectifying diodes are connected to separate the two components of the roughly 12V output supply from the involved transformer. The result holds ripple (little component of the A.C. mains). It is removed or minimized through a parallel connected capacitor (L1, 2700uf 25V). A power switch (5w1) is incorporated into the design to open and close the altogether circuits. A resistor-diode circuit is used to indicate the pressure of power supply to the circuit. A 7808 integrated circuit supplies a regulated output of 5V to the circuit. The regulator provides reasonable voltage stability in the circuit.

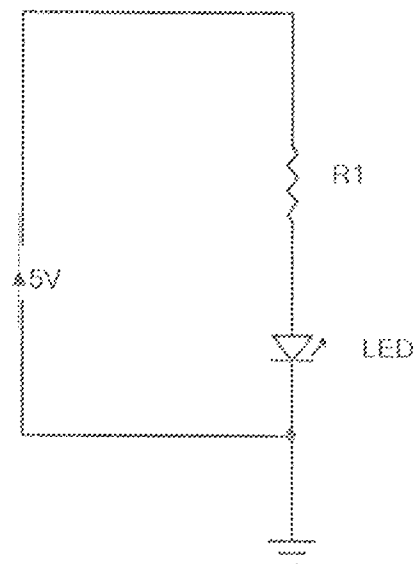


Fig.3.12. The power indicator circuit

Normal Light Emitting Diodes (LED) has maximum voltage rating of 2.8V. In this case, while the supply voltage is 5V, the light indicator needs a series resistor for voltage drop. The typical current for this circuit is roughly 3.5mA.

Therefore,

Voltage across the LED is expected to be 2.8V

Voltage across the resistor is $5 - 2.8 = 2.7V$

So, $R_1 = \frac{2.7}{3.5 \times 10^{-3}} = 628.6\Omega$

1K Ω is more practical. It is quite close to the calculated value.

3.4.2 Crystal oscillator/divider unit

The main function or task of the unit is to provide necessary timing for the circuit. It is the heart of the altogether design. Interestingly its operation is at the crystal mode. Therefore, reasonable accuracy is attributed to the design due to the crystal attachment [1].

This unit holds a 4060B and 4518B. The 4060B generates a main frequency (32768Hz) which is internally divided and further division done by the 4518B. The result is a timing positive timing of 1 second and other control signals. The 1 second timing pulse is used for enabling input signals for measurement.

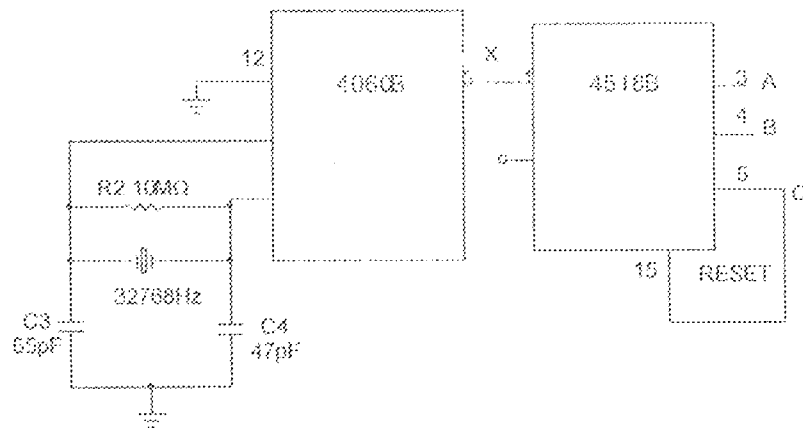


Fig. 3.13. The crystal oscillator/divider unit.

The 4060B works with the 32768Hz crystal to generate the smallest output of 2Hz. The value of C_3 , C_4 and R_2 are 65pf, 47pf and 10m Ω respectively. Their values are specified by their respective data sheets. Pin 3 of 4060B is at 2Hz. And, the value is derived from the output formula of the integrated circuit. Pin 3 of 4060B is Q14

Therefore,

$$F_{Q14} = 32768/2^{14} = 2\text{Hz}$$

This output is connected to the clock input of the other device (4518B). Although, this device is designed as 4-bit BCD up counter, the device is a useful divider. Based on normal counter principle of operation, when the input clock (at Pin 1) is 2Hz, terminal A and B are 1Hz and 0.5Hz respectively. The feedback at Pin 33 to the reset (Pin 15) is due to prevent irregularity from free operation of a BCD up counter divider.

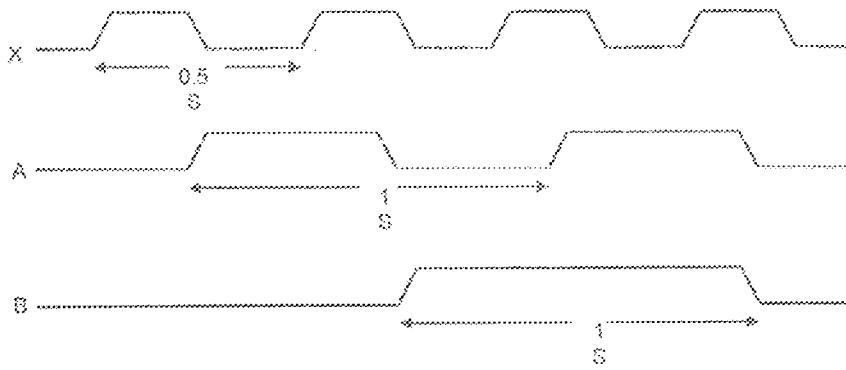


Fig. 3.14. The expected waves form at point X, A, and B.

3.4.3 Control logic unit.

The control logic unit is designed to coordinate the input with the output of the entire circuit. The unit holds three 3-input AND gates and two NOT gates. Their combined connection results into three logical operations. The control logic unit opens the input for exactly one second to allow frequency measurement, latch the result of the input counter in the display decoder and reset the involved counter for fresh counting of a new one-second sampled input. Therefore the control logic operates in circle; it merely repeats the duties over and over again [2]

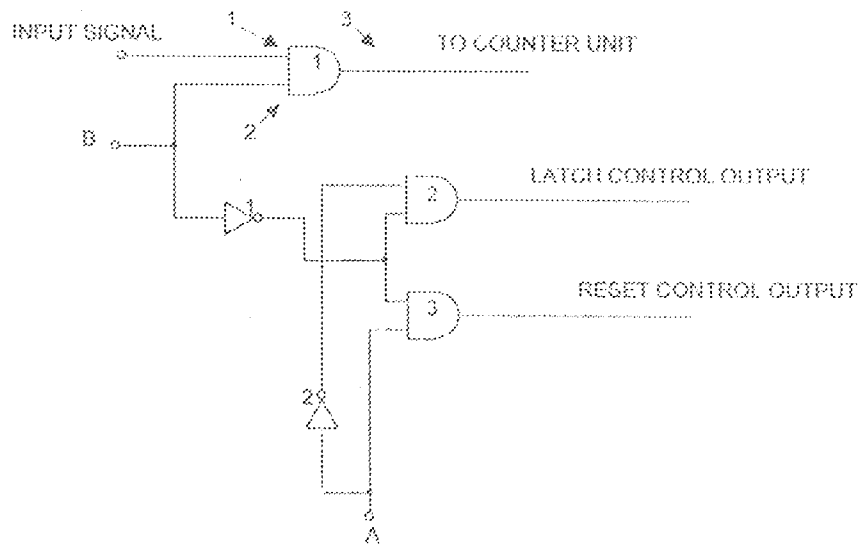


Fig. 3.15. The logic control unit.

Starting with AND gate 1, signal B controls the enabling of the AND gate. The signal opens the gate for one second for the input to flow through the gate to the output. The high and low part of signal B is one seconds each. This is because its frequency is 0.5Hz. Therefore, the period is 2 seconds.

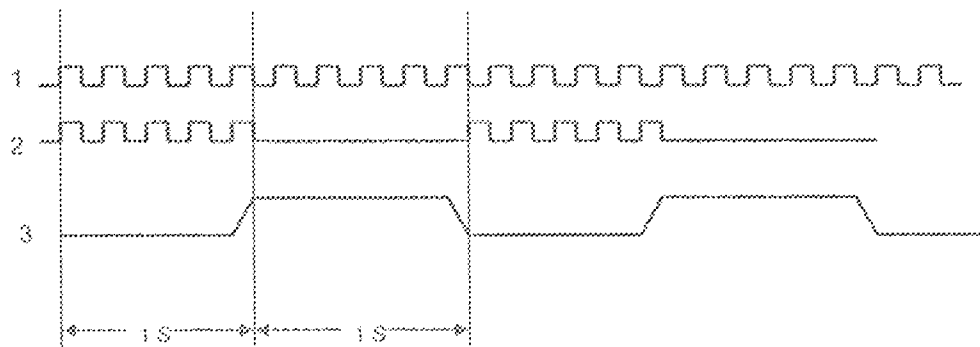


Fig. 3.16. Signals at AND gate 1

Therefore, AND gate 1 is used for sampling the measured input signal. The fact is that frequency is the number of cycle of a uniform signal or pulse in a second.

The positive portion of B does the sampling operation. The negative portion is required for the other two tasks. Signal B is connected to inverter 1. The inverter allows AND gate 2 and 3 to be enabled at the negative side of the control signal. Signal A is also connected to another NOT gate (inverter 1). So the AND gate 2 and 3 do not work at the same time.

The connection involved in the control logic unit allows three pulses to come high one after the other.

3.4.4 Counter unit.

The counter unit is designed to count the number raising level of an input signal in one second. The corresponding count or number is the frequency of the measured input signal. The counter unit holds five BCD up counters. They possess asynchronous cascading configuration. They have a common reset terminal. The counters provide a maximum count of 99999. Each counter represents a particular digit.

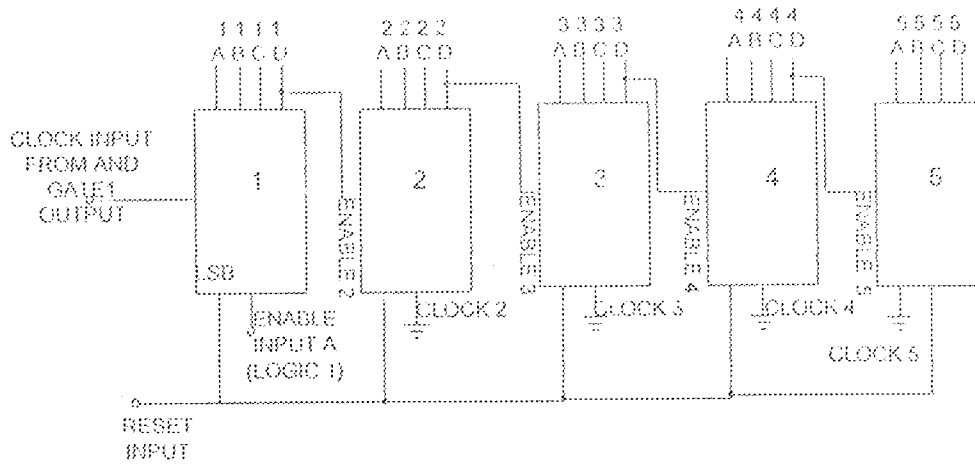


Fig. 3.18. The counter unit

The counter unit receives input signal through the clock input of the LSB counter. The signal comes in for just one second. Although, the counters are asynchronously cascaded, they result into insignificant delay. This is due to low relative frequency of the circuit. The frequency is far below the maximum response of the involved logic.

3.4.5 Display unit.

The display unit mainly consists of five 4511B (latch/decoder) and five seven common segment displays. They are designed to convert the code of the counter into visual information. The 4511B integrated circuits possess latch feature for holding a

finished result of the counter during input sampling. The feature allows fresh sampling of the input while the initial result is still on the display panel.

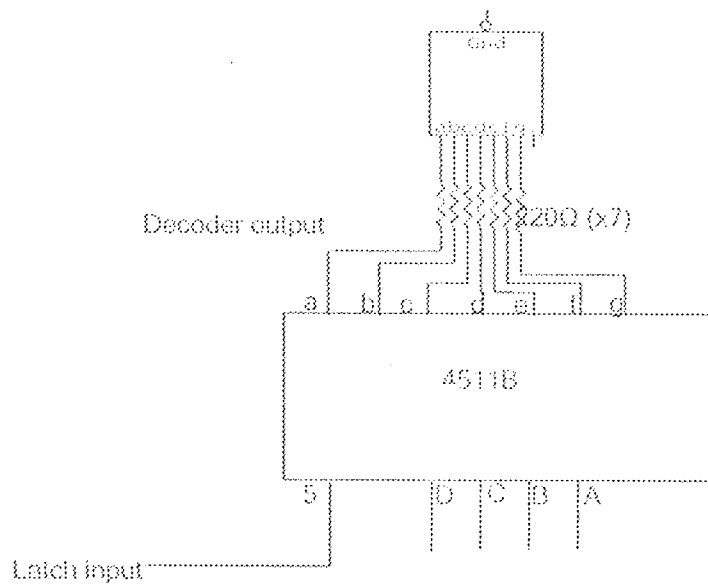


Fig. 3.19. A single part of the display unit.

The above circuit shows a single display path. It involves one 4511B, seven 220Ω resistors and a single common cathode 7-segment display. The involved resistors act to bias correct voltage at each segment of the display. At normal situation, each segment must be at about 3V. The resistors provide the voltage drop from the related 5V supply.

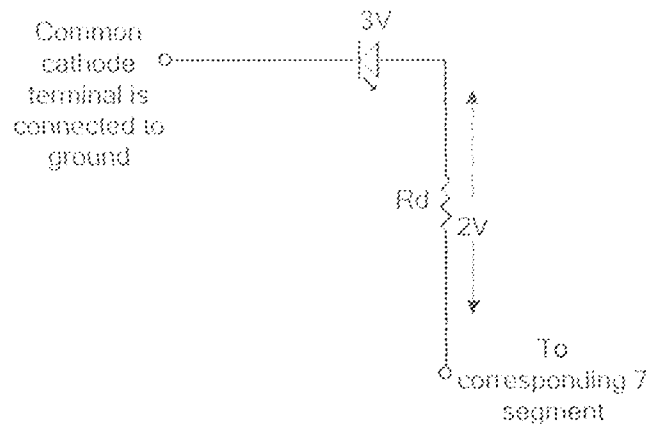


Fig. 3.20. A single segment circuit of the 7-segment display.

The voltage at the resistor is 2V. Assuming a typical current of 6mA

$$\text{Therefore, } R_d = 2 / 6 \times 10^{-3} = 333.33\Omega.$$

220Ω resistor is used instead of the calculated value.

3.5 Summary of the operation of the circuit.

The project involves a crystal oscillator/divider unit that generates required timing for the whole circuit. The most important signal is for one-second sampling of the measured signal. The concept is all about the measuring of frequency: the number of wave cycle in one second. A control logic unit is used to control the response to the input signal. A counter unit is directed to count the number of high rising portion of the input signal in a second.

Also, the control logic unit uses the timing from the crystal oscillator/divider unit to direct the result of the counting operation into latches inside the display unit. The latches hold a finished input counting result, while a new result is set upon. The

counting result is displayed on a LED display panel. The result is the frequency of the input signal which must be within 0 – 99999Hz range.

CHAPTER FOUR

4.0 CONSTRUCTION, TESTING AND RESULTS

4.1 Circuit construction

The main construction of the circuit was performed on a Vero board. The Vero board mounting was after the circuit underwent proper check on board bread. It involved temporary connection of the entirely involved components. The important of the test was to be sure of the workability of the circuit diagram. The procedure resulted into the adjustment of value to certain components for better performance. Resistors were more considered with such adjustment.

The components were carefully connected to the board with the use of soldering iron.

Moreover, the Vero board procedure involved permanent or more fixed connection of the involved component. All involved integrated circuit went along with corresponding sockets. Sockets protect integrated circuits from heat destruction during soldering operation. Other components such as capacitors and resistors are directly mounted into the board. Related components were put closely together.

Thin connecting wires were used to link point to point. The connection followed the circuit diagram. Some wires were glued to the board for more rigidity. The removal of these wires after soldering was quite avoided. Also, close contact were insulated through the application of glue.

The complete Vero board mounted circuit was checked for short circuit and unwanted bridges. The check was carefully done due to the consequence involved in connecting a circuit improperly.

4.2 Casing construction

The casing construction involved the adoption of a normal CD-ROM casing for the circuit. Its size is quite suitable for the circuit. The adoption was quite mere. It only involved printing, cutting and covering of open-edges.

The casing was printed with white automobile print. The resulting appearance provides more importance to its appearance as contrast to the initial colour. The cutting was performed in the flat section of the casing so as to expose the involved 7-segment display panel of the circuit. The cutting was carefully done by putting the dimension of the overall display panel. Also, open points on the casing were covered with flat plastic sections. The casing was given a finished appearance by proper placement of the attachments.

Moreover, the circuit was fixed inside the casing through suitable bolts and nuts. The attachments provide the circuit firm placement into the casing. Some points on the casing were insulated to prevent direct bridging of the circuit through the metallic surface of the casing.

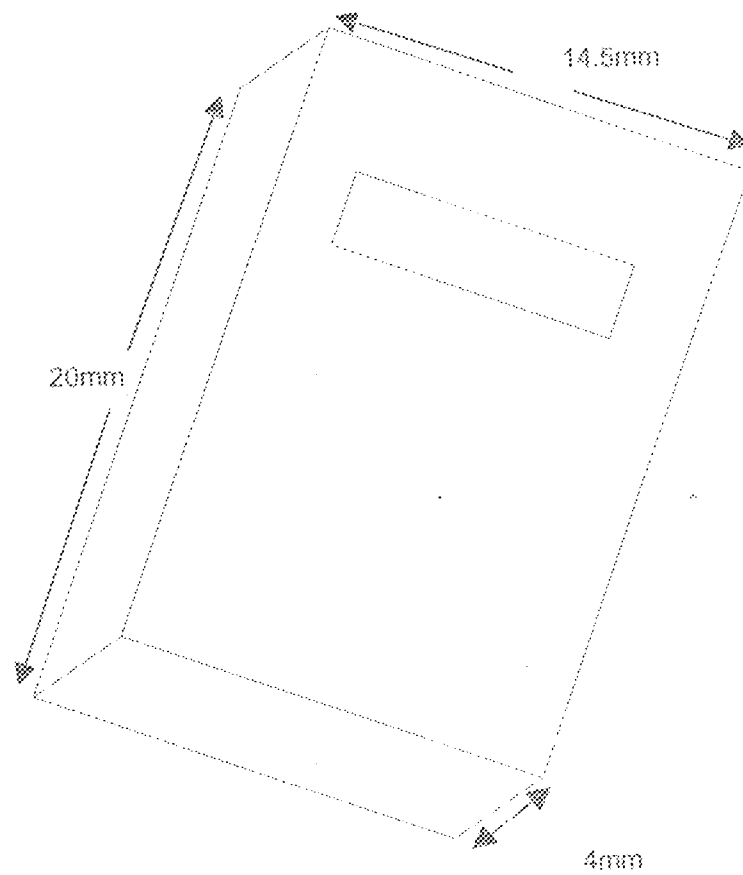


Fig 4 the casing dimensions

4.3 Testing

The testing of the circuit was performed in the laboratory. The test involves the complete circuit and a signal generator. The generator was used to provide suitable known frequencies into the device. The output of the frequency meter was contrast with the known frequency inputs.

The involved signal generator was Philip signal generator and amplifier. It is designed to generate frequency range 10Hz to 100 KHz. Although, the test was limited to lower outputs. The frequency output of the device was fed out through a 2-wire cable. One of the wires was signal output, while the other was ground. Because the two

frequency meter and generator) were operating on different power, their grounds were required together or as one for normal current flow.

A particular frequency was adjusted in the frequency or signal generator. The signal was well stated on the dial. And, the frequency meter was required to read out the frequency. Related observations were made at steady condition to prevent reading error.

The frequency meter was tested with the frequency of signal generator numerous times for a reasonable conclusion. Most tests were performed within the expected frequency range of the frequency meter. Few tests were done out of range of the meter. They were merely aimed to justify the involved design specifications. Moreover, every test was carried out for acceptable result.

Results

The results merely reviewed the performance and accuracy of the device. Each test outcome was expected due to the already confidence in the circuit. In fact, little error was attributed to the frequency meter.

The test results are given below:

Table 3.5. Result

no	Input signal (Hz)	Reading on the frequency meter (Hz)	Difference (Hz)
1	1000	1001	-1
2	2000	2000	0
3	3000	3000	0
4	4500	4499	1
5	5500	5500	0
6	7000	7001	-1
7	8000	8001	-1
8	9000	9001	-1
9	9500	9499	1
10	10000	10000	0

CHAPTER 5

CONCLUSION

The aim of the project was met, the end product was to specification

RECOMMENDATION

- i. The frequency range of the device could be expanded for better application and response.
- ii. The LED display could be replaced with LCD type for lesser power consumption.
- iii. The device could be incorporated with a period reading feature. So that each frequency reading goes along with its corresponding period.
- iv. A microprocessor could replace the numerous involved integrated circuits for more portability.
- v. The device could be modified to be interface with a computer. This feature provides more functions for the application.
- vi. The device could be converted to a precision frequency generator for more accurate frequency analysis.

PRECAUTIONS

- i. Integrated circuit's sockets were used to protect each involved integrated circuit to prevent them from heat destruction during soldering.
- ii. The circuit was properly tested for short circuit before plugged.

- iii. Reasonable information on the involved components was accessed before they were incorporated into the design.
- iv. Some sensitive wires were properly glued to the working board to prevent their removal.
- v. Certain parts of the circuit were properly insulated to prevent short circuit during casing which involved metallic material.
- vi. A voltage regulator was incorporated into the circuit to prevent components destruction during over-voltage from the mains supply.

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APPENDIX.