A PROJECT REPORT

ON

DESIGN CONSTRUCTION AND TESTING OF AN ULTRASONIC FLAW DETECTOR

BY

TIYAGNET ELISHA DUNIYO

DEPATMENT OF ELECTRICAL/COMPUTER ENGINEERING
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA,

NIGER STATE, NIGERIA.

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CERTIFICATION

I certify that Mr. Tiyagnet Elisha carried out this project work, and that he has met the minimum standard demand acceptable by the Department of Electrical and Computer Engineering Federal University of Technology, Minna.

MR. KENNETH PINNE **DATE**

SUPERVISOR

16/1/01

DR. ADEDIRAN **DATE**

HEAD OF DEPARTMENT

17/1/01

EXTERNAL EXAMINER **DATE**

DECLARATION

This is to declare that I, Tiyagnet Elisha of the Electrical and Computer Engineering Department of the Federal University of Technology, Minna, carried out this project. Under the supervision of Mr. Pinne K.

SIGNATURE OF STUDENT

DEDICATION

The above named project is dedicated to Almighty God who saw me through all the five years I was in school.

ACKNOWLWDGEMENT

I give praises to god Almighty who taught me how to be a good engineer to test metals with my God given skills. I will never forget my dad who proved to be my very own best friend in the good and bad times, in riches and when I am broke. My gratitude goes to my comrade Amos Peter who got the vital information handy. Amos showed me courage, patience, and support irrespective of my wrong doings. My cherished Emmanuel Oladayo Olawuyi who has been a friend, room mate, co-worker, brother, classmate and any good thing

ABSTRACT

Ultra sound is a mechanical wave, which can travel in air, water, oil and even metal. Operating a metal test with ultra sound at frequencies between 40,000Hz and about 80,000Hz by use of a voltage controlled oscillator (V.C.O). pulses are sent to the medium to be tested. Faults are detected by observing echo of the transmitted wave, which occur in a time period that is different from that which conforms to the metal's dimensions. Thew metal's dimension is put into account by varying the time to travel of the ultrasound by varying the pulse frequency via the V.CO. as stated above. The timing is observed on a time scale provided by an array (bar) of light emitting diodes. The frequency of operation depends on not only the metal piece but also its permeability to the wave.

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CHAPTER ONE

1.1 INTRODUCTION

Metals were discovered thousands of years ago thus marked the end of the Stone Age. Metal crept into man's life in if not all many areas; aviation, automobile, engineering, agriculture, defenses just to mention a few. Metal does not come wrought in tablets but have to be mined, smelted, processed then molded to commercial sizes. Over many decades, inpefections, blowholes and strain cracks. In the engineering industry, good engineering management means good economy and efficiency. Environmental impact is measured by industrial efficiency. The quality control of products goes a long way in shaping man's livelihood. The most economic way to check the integrity of a piece of mass is by testing it without destroying it. Non- destructive testing can only be achieved by using harmless energy at low cost. Good examples are the use of laser, ultraviolet rays,'X' rays, 'Ÿ' rays and ultrasonic waves.

In the metals field, ultrasonic testing and inspection is one of the most useful nondestructive methods. It has been accepted as an economic necessity by mills, forgers, fabricators, railroads, and insurance companies.

Faults and blowholes occur in freshly prepared ingots. It had been very difficult to know weather a metal piece is free of such imperfections. Archimedes' principle was used in determining weather the king's crown is genuine. Nowadays sophisticated equipment is being used in testing metals.

1.1.1 HOW IT WORKS

The flaw detector has two output signal types namely audio and visual respectively. A beep is heard indicating flaws via a headphone set or in built buzzer if the user unplugs the phones' plug off its jack. Alternatively, a time base bar display displays the visual output.

The voltage-controlled oscillator controlled by the user manually generates a variable sweep time. This in turn varies the time for the ultrasound to travel through the medium. This same travel time is the refreshing time for the receiver module to read echoes that occur as the fundamental principle behind fault detection.

The trick here is that sound is a mechanical wave longitudinal in nature. Sound travels about 330 meters a second in air at atmospheric pressure. The atmospheric pressure is one of the major factors responsible for the density of the air fluid. Secondly, the velocity of a wave depends on the properties of the medium it traverses. The property of interest is density. As a wave leaves one medium to another there is change in velocity thus a change in velocity. This change in velocity results to transmission termination effects that cause partial absorption, reflection and penetration of the source wave. A coefficient of refraction is thus formed and leads to reflection when incident angles are critical.

The controlled oscillator generates pulses for which one out of thirty-two pulses is used for transmission as synchronizer bit. The rest of the fifteen pulses are used for reading time mode that is the read echo state. This means that it has two states, which are the send state, and the read state. Looking at fig 1 the dimensions of the test piece can be used to represent the time the ultrasound traverses the medium.

Ultrasonic frequency came se a result of the speed of the wave in the metal. Transducers that can handle the energy conversion are quartz crystals that can operate bi-directional. A single transducer can do both transmission and reception of sound. This leads to two approaches namely single transducer test and dual transducer test. The single transducer method requires beaming the piece at 90^0 to the surface while the dual uses acute angles which transmission and reception location differ.

1.1.2 FLAW DETECTION

For flaw detection, there are three regions of interest found on the work piece that are;

(A) The immediate boundary; this is the first phase change where some reflection occurs between the transducer and the metal piece tested. This reflection does not indicate any flaws in the metal.

(B) Internal boundaries (interstitial openings); reflections occur here only if there is a foreign body embedded in the base medium metal. This is the middle of the refreshing period. Echoes here indicate flaws.

(C) The remote boundary; this is the change in medium at the other end of the metal piece. Echoes also occur here and do not indicate flaws.

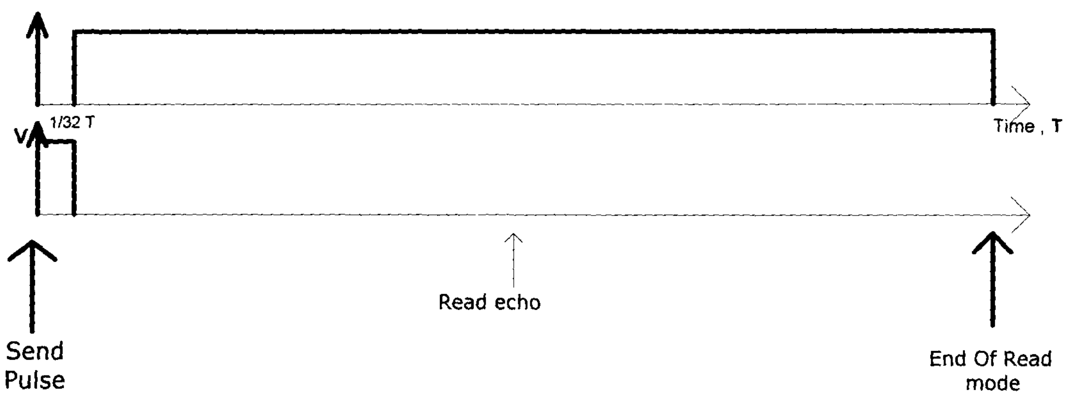


Fig 1.1.2 ; Time Scale For Flaw Detection

With regards to fig 1.1.3, flaw detection is easier done with two transducers with ∅ less than the angles of refraction of the media exchange this varies with the metal and is about

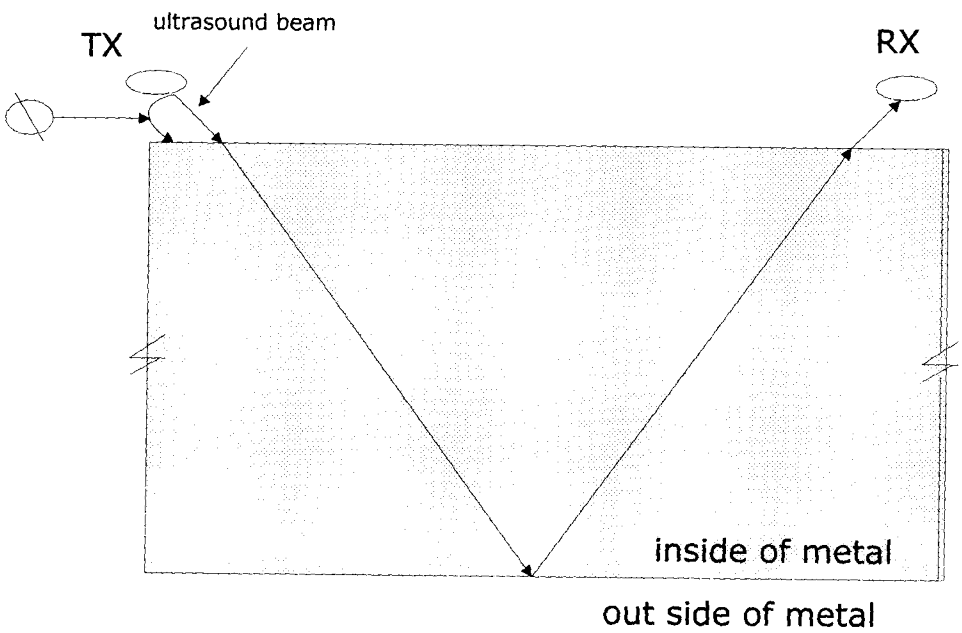


Fig 1.1.3 Beaming ultrasound Into Metal.

1.2 LITERATURE REVIEW

A brief discussion on what man has done with ultrasound best describes the kind of ultrasonic instrument designed.

Necessity they say is the mother of invention. Thomas Edison discovered how to store sound ... by recording. Since the time man discovered sound to travel through different media metal could then be tested based on the phenomenon that different mediums always have different permeability to sound thus having different velocities for their hosted ultrasound wave.

Scientists and engineers in many countries have contributed to the development and perfection of ultrasonic inspection since the early twentieth century.

Sokoloff, in Russia, and Pohlman, Trost, Kruse, and Mulhouser, in Germany, were among the first to investigate thorough transmission using continuos waves. Bergman's "Der Ultraschall" is still one of the principal references on the principles of ultrasonic testing. In England, Glass, Rankin, and others interested in nondestructive testing developed equipment of the pulse type applying two crystals. In the U.S, Firestone, Fredericks, Erdman, Wild, Reid, Carlin, Howry, and many others contributed to the design and improvement of pulse type ultrasonic testing instruments, defect recording and signaling accessories, and scanning mechanisms.

Blessing et al (G.V, Blessing and D.G. Eitzen) 1988 investigated the use of an ultrasonic surface measurement system. This he used for the surfaces of machined products. He sent ultrasonic pulses at incidence angle 90 degrees to the surface line and received echoes of amplitudes proportional to the surface roughness values.

His surface estimates were got from the 'coherent pact' of Kirchoff's scattering model with amplitude distribution.

CHAPTER TWO

2.1 TRANSMITTING MODULE

This consists of a buffer and the logic circuit that realizes the send bit. More on the source code for the send pulse is discussed in section*****.

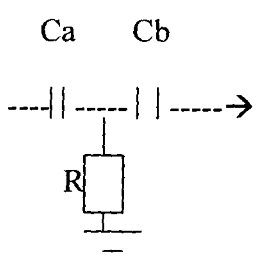
2.. RECEIVER MODULE

This module is aimed at recovering any reflected wave of sound, converting it into electrical voltage that should be compatible with the next module, which is a digital circuit of the CMOS family.

This is broken into major parts.

1. Pick up amplifier.
2. Voltage amplifier
3. Voltage converter (wave shaper).

The pick up amplifier consists of the receiving terminal and a high pass filter of the R. C network type.



For the transfer function,

If Iout = 0 (the output connected to an ideal op.amp of Infinity input impedance) then the circuit reduces to Ca and R

$$Vout = \frac{Vin\ Z_R}{Z_c + Z_R}$$

$$\text{But } Z_c \frac{1}{J\omega c} = \frac{1}{j2\pi fCa}$$

$$= \frac{-j}{2\pi fCa}$$

And $Z_R = R$

$$\text{This FF.} \Rightarrow \frac{Voat}{V1^2} = \frac{Z_R}{RTZ_C}$$

$$= \frac{R}{Rt\,(1/j2\pi fC)} = \frac{j2\,f\,RCa}{j2\pi fRCa + 1}$$

Using S – domain; $T.F = \frac{SRCa}{1 + SRCa}$ $\lim_{S \to 0} [T.F] \Rightarrow 0$

$$\lim_{S \to \text{infinity}} [T.F] \Rightarrow 1$$

A Zero for T.F. exists at 8 = 0 only S = jω and D.C. is that kind of voltage which S = 0. This filter blocks D.C from flowing in through the circuit. The input frequency of the flaw detector various due to metal dimensions and for this reason tank at is not used since it accepts only a particular frequency. RCa is calculated at T.F > o.5 at f > 20 & H_z. RLa = 7. 957×10^{-6}, R = 780Ω and Ca = 0.0 1μF.

2.2 VOLTAGE AMPLIFIER.

This consists of two operational amplifier stages cascaded together for high voltage goes in. The received pulse or wave form from the metal is very weak that is why it is high input impedance for a better performance the gain in voltage is pre settable.

$$\text{Gain} = Av = \frac{Vout}{Vin}$$

Vout is required to be as high as 8.Vpp for a comfortable working of the voltage wave converter module. The input voltage 'Vin' can very due to metal attenuation and transducer efficiency. Vin rages between 50 V to 0.1mV.

The gain should vary between

$$\Rightarrow \frac{8}{50 \times 10^{-6}} \quad \text{and} \quad \frac{8}{0.1 \times 10^{-3}}$$

$160 \times 10\ 3^3 < Av$ $< 80 \times 103$

One of the opamp stages will have a fixed voltage gain and the other variable. The one with fixed Av will have its voltage gain not greater than 80×10^3

The variable one depends on the sensitivity of the device. Its voltage gain can be designed to very between unity and the ratio of the highest voltage gain to the constant voltage gain

Av max = 160k, Av min = 80k

Av const = 80k, Av1 min = $\frac{Avmin}{Avconst} = 1$

Where Av_2 is the constant voltage gain (Av_{const})

$$Av_1 \text{ max} = \frac{Avmax}{Avconst} = \frac{160k}{80k} = 2$$

But in practice 80,000 is too high a voltage gain for an opamp. A real opamp can have open – loop gain less than that. To solve the problem, Av_1 and Av_2 can equally share their gains. Finding the square root of the maximum gain does this.

Here; $n\sqrt{(Av_{max})} = Av_i$ ...Where n = No of op.amps used

i = the particular opamp of interest.

N = 2, Av max = 160,000

:- $Av_i = 400$

This first op.amp can have a fixed gain of 4oo and the second have a variable of

80,000 $< Av_2 <$ 400400

$200 < Av_2 < 400$

The two op.amps are inverting amplifiers.

Thus using $-RF = \frac{Av}{Ri}$ then for $AV_1 = 400$ then $Rf_1 = 400\ Ri_1$

From table of resistors available in the market. A combination of 1.2 KΩ as Ri and 470 k Ω as Rf will considerable give a gain does to 400.,

$$\text{Practically } Av1 = \frac{470\ \&\Omega}{1.\ 2\ \&\ \Omega} = 391.667.$$

This makes Av_2 to have a maximum gain of 408.51 to be precise.

Av_2 will have a minimum of 204.25

For this op.amp. RF_2 will have variable value

$$\frac{RF_2\ max}{\_Ri_2} = \frac{AV_2\ max}{1} = 408.\ 51: Ri_2 \quad \text{--- (1)}$$

This RF_2 max = 204.75 Ri_2 ----(2)

$VR_1 = RF_2$ max - RF2 min = Variable component of RF2 Variable resistors come in powers of ten and multiples of five RF2, variable part has to be chosen.

Let RF_2 max - RF2 min be = 100k Ω ---- (3)

Then a matrix can be formed.

$$\begin{bmatrix} RF_2\ max & + & 0 & 4o8.51\ Ri_2 & = & 0 \\ 0 & + & RF_2min & 204.\ 25\ Ri_2 & = & 0 \\ Rf_2\ max & - & Rf_2\ min & +\quad 0 & = & 100k\ 10^{3} \end{bmatrix}$$

Substituting (1) and (2) into (3)

$2Ri_2 - Ri_2 = 489.596$

$Ri_2 = 488.596\ \Omega$

470Ω can easily be got from the spare ports shop

Thus $Ri_2 = 470\Omega$

Thus Rf_2 = 470 x 204.25 = 191. 997 & Ω

= 200k Ω

Rf_2 min = 470 x 204.25 = 9599.7.5 Ω

= 92kΩ

92 k Ω is available also in spare parts shops.

For coupling both op-amp stages a coupling capacitor is used. This is because the signal we are interested in is an A.C voltages waveform. The value of this coupling capacitor is ideally large so as not to offer reactive impedance to the ultrasonic frequency voltage signal.

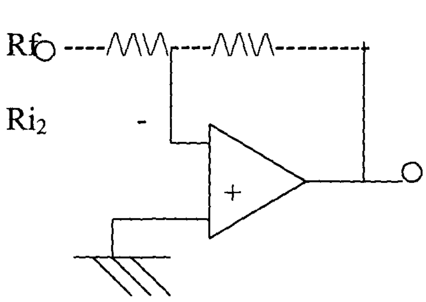
$Zc = \frac{1}{2\Pi C}$ ..... if f > 20kΩ then Zc = 7.95μF.

Zc approaches unity as C approaches 7. 95μF. At least Zc must be less than unity than C > 7.9 μF

C hero can by bought as 10μF from the shops.

2.3 WAVE FORM CONVERTER / CONVERSION

This is simply a rectifier used as a detector for the echoes received from the work piece. Incorporated with the network is a difference amplifier. The involvement of the difference amp here is owing to the fact that the detector cannot transfer a common (ground).



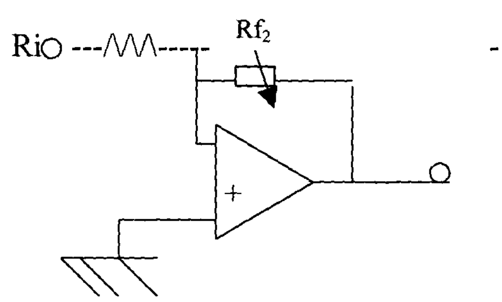


Fig ..2.3. Voltage amplifier stages

The rectifier can only be grounded at one side which is the A.C side since it is found from a single output op-amp which must works with ground of the rectifier without need of ground.

The transfer function of the rectifier is $\frac{2\ Vm}{\pi}$. ...where Vm is the amplitude of the output of this amplifier module. The rectifier is bridges of germanium diodes have a low forward voltage drop. This improves the efficiency of this rectifier (the expression, " $2Vm/\pi$" is for ideal diodes).

2.4 THE DIFFERENCE AMPLIFIER.

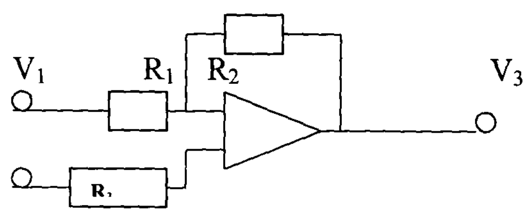


FIG .2.4. THE DIFFERENCE AMPLIFIER

R_3 = R_1)R_2 _to reduce input biasing currents R_3 thus depends on R_1 and

R_2 $V = \left(\frac{R_1 + R_2}{R_1}\right) V_2 - \left(\frac{R2}{R_1}\right) V_1$

If $R_2 >> R_1$ then $R_1 + R_2 // R_2$

Since most of voltage amplifier ion is achieved by this previous 2 – stage cascaded voltage amplifiers this gain here is not article.

The gain $\frac{V3}{V_2 - V_1}$ is approximately $= \underline{R_2}$ (where R_2 >>) Note that V_3

should saturate when ever a difference in V2, V1 voltage exists. A gain of 20 can be estimated 20 = R2 thus R2 = 20R1

C_5 is the filter capacitor; R_{16} is the bleeding off resistor. R_{16} discharges C_5.

Using ripple% = $(v_{dc}*t)/(R_L*C)$

$R_L = R_{16}$ and $C = C_5$

But t is = 1/f ... where f is the frequency of the ripple.

For the largest t (lowest frequency)... t= 1/20KHz

= 50μ sec

For the smallest t, > t = 1/ upper freq.

Since minimum ripple is required minimum f is used so that the largest value of C is determined and after it is kept constant smaller ripples will exist.

t = 50μsec

It happens that $v_{dc} = 2v_m/\pi$... Where v_m varies with reception of echoes.

It is desired that v_m gets above circuit noise and best be approaching v_{dd} value. A compromise of half v_{dd} for v_m is reached. v_{dd} is nine volts!

$$9/2 = v_m = 4.5v$$

$$4.5x2/\pi = 2.86478v$$

Thus $2.86478xt/R_LC$ = ripple% = $2.86478x50usec/R_{16}C_5$;

$$R_LC \text{ is} = 143.239\mu\Omega F$$

Choosing 0.1μF for C_5 then R_{16} = 1.4329KΩ

$$\approx 1.5K\Omega$$

Observing the schematic diagram, R_{18} and C_9 are synonymous to the R_{16} and C_5 network thus the same values of R_{16} and C_5 are used for R_{18} and C_9 respectively.

2.5 TONE GENERATOR

Audible sounds of high pitch are easily heard in a relatively noisy environment like the premises where metal testing is been done. Tones of 1.5KHz are easily distinguished by human ear.

Using the HA17555 timer I.C, which is of the M.O.S type, The formula for the astable connection is > 1.44/((Ra + 2Rb) C) = 1500

Choosing 0.1 μF for C> Ra + 2Rb = 9.553KΩ

For a good duty ratio; Ra<<Rb taking Ra to be about 10%Rb, Ra ≈1.0KΩ

This leaves 2Rb = 9.5KΩ - 1.0KΩ

Rb = 4.25KΩ…≈4.7KΩ

On the schematic diagram, Ra =R_4, Rb = R_5.

(2) With power dissipation of 1. 2. M W per gate at switching frequency of 1MHz. Voltage supply can vary with most and B between 3V and 15 V, which makes it suitable for potable circuits. A simple 9v battery can power this device as a result of low power dissipation. Other contenders such as the TTL (74 xx series); ECL and RTL are faster but dissipate 2 mW/gate for the L S and about 5mW/ ca to for the schottky (74Sxx)

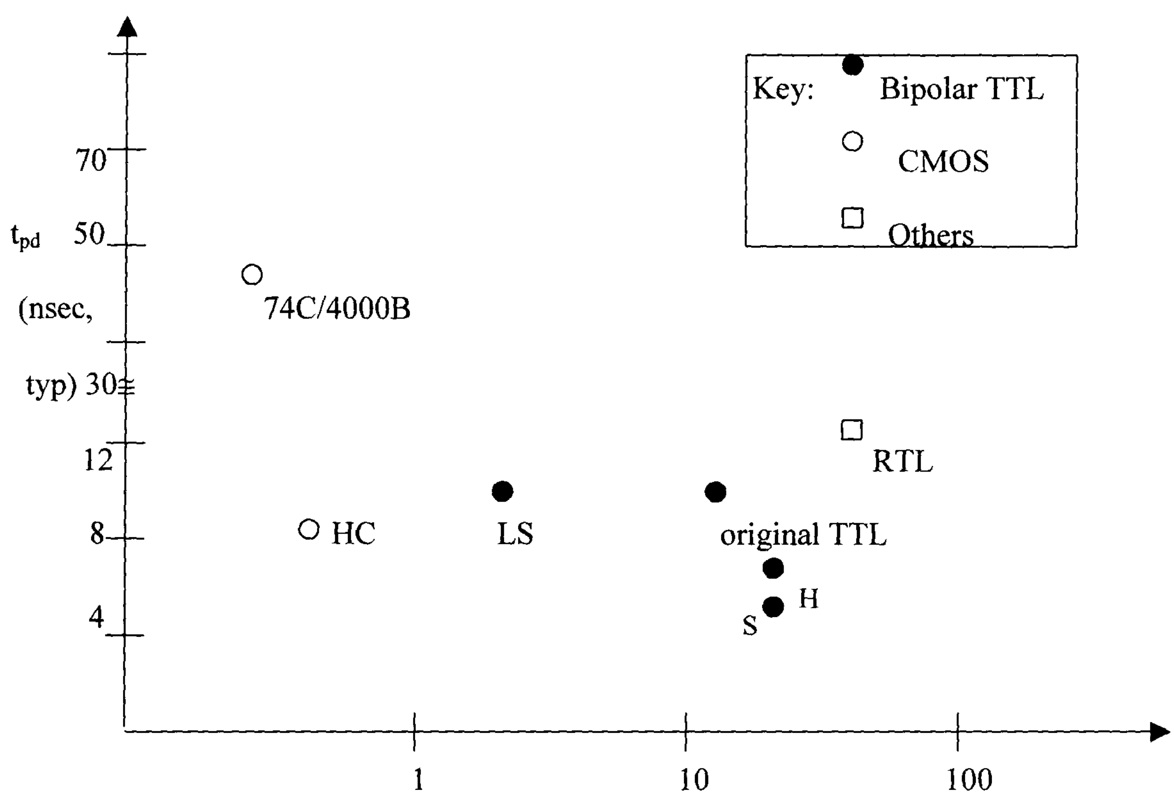


Fig 2.5 Point chart; Speed versus power dissipation for various logic families

The ultrasonic flaw detector runs at various frequencies. The frequency is adjusted to get job piece dimensions. Table gives different media which ultrasound travel at different speeds and attenuation levels. Polling the velocities, a mean velocity was chosen to get an idea of the time to travel for the pulse.

2.6 READING INSTRUMENTATION MODULE

This module enables the user get information on the internal structure of the job piece tested. This part of the circuit is aimed at discarding the need for a cathode ray instrument, which is bulky and expensive. Features for reading data from echoes are

1 . Time; the circuit should tell when the echo occurred

2 . Synchronization; distinguishing between reading and writing time accurately.

The above aim can be achieved either digitally or by analogue means.

The digital style is chosen because of its obvious advantages over analogue. Digital designs are structured and easy to maintain or diagnose despite the relatively large hardware. Digital circuits give the highest grade discrete parameterising. The digital circuit can give a more accurate time for echo read depending on its resolution. The resolution chosen here is thirty-two for a bar. This figure is chosen because it is a perfect square of two, which makes the circuit design simple. The circuit divides the time to travel of the ultrasound into thirty-two discrete parts displayed as a bar (array) of L.E.D.s. The pulse received from the wave shaper is processed (demodulated) to show on the bar section relevant to the time lapse the echo occurred. Below are design steps:

1 Form a truth table

2 Translate the truth table into Karnough maps.

3 Write down the most suitable Boolean expression for each map.

4 Do term minimization on each equation or expression.

5 Conjecture a simple suitable circuit to realize the above written Boolean expression.

6 Interface all simple circuits together to form main schematic.

2.6 STATES TABLE

This table takes the format> state/input/output.

The STATE and INPUT show all possible states. These are lettered A.B.C.D. and E. The input labeled 'echo', which is the received echo, bit from the job piece. The outputs are the 'beep bit', and 'WR', which writes to a pulse for transmission.

The table is sixty states wide found in page 25 .

2.7 MAPPING.

From the state table Karnaugh map size becomes the square of 8 by 8 cells with grey code transitions.

From >000>001>011>010>110>111>101>100

However , due to similarity of maps, maps of L.E.D.s #1;#2;#31;#32 are shown. The other maps can be imagined by using a pattern similar to the identity matrix. The modulo of the L.E.D.s are odd numbers starting from 3 to 5 to 7 to.......to 31 for L.E.D.#1,2,3,.....,16 respectively. L.E.D.#17 to #32 have decimals 33 through 63 respectively.

Table 1; L.E.D.#1 Map

ABC / DE echo	000	001	011	010	110	111	101	100
000	0	0	0	0	0	0	0	0
001	0	0	0	0	0	0	0	0
011	1	0	0	0	0	0	0	0
010	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0
111	0	0	0	0	0	0	0	0
101	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0

Table 2; LED # 2 Map

ABC / DE echo	000	001	011	010	110	111	101	100
000	0	0	0	0	0	0	0	0
001	0	0	0	0	0	0	0	0
011	0	0	0	0	0	0	0	0
010	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0
111	0	0	0	0	0	0	0	0
101	1	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0

Table 3; LED 31 Map

ABC / DE echo	000	001	011	010	110	111	101	100
000	0	0	0	0	0	0	0	0
001	0	0	0	0	0	0	0	0
011	0	0	0	0	0	0	0	0
010	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0
111	0	0	0	0	0	1	0	0
101	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0

Table 4; LED # 32

ABC / DE echo	000	001	011	010	110	111	101	100
000	0	0	0	0	0	0	0	0
001	1	0	0	0	0	0	0	0
011	0	0	0	0	0	0	0	0
010	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0
111	0	0	0	0	0	0	0	0
101	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0

Table 5; Map for Beep bit

ABC / DE echo	000	001	011	010	110	111	101	100
000	0	0	0	0	0	0	0	0
001	0	1	1	1	1	1	1	1
011	0	1	1	1	1	1	1	1
010	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0
111	1	1	1	1	1	0	1	1
101	1	1	1	1	1	0	1	1
100	0	0	0	0	0	0	0	0

Table 6; WR Map

ABC / DE echo	000	001	011	010	110	111	101	100
000	1	0	0	0	0	0	0	0
001	1	0	0	0	0	0	0	0
011	0	0	0	0	0	0	0	0
010	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0
111	0	0	0	0	0	0	0	0
101	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0

BOOLEAN EQUATIONS

From fig >Beep bit = $A\bar{D}echo + \bar{B}Decho + \bar{A}C\bar{D}echo + \bar{A}CDecho + \overline{BC}Decho + B\bar{C}Decho$

Using the absorption principle > Beep bit = $A\bar{D}echo + \bar{B}Decho + \bar{A}Cecho + B\bar{C}echo$

Factorizing 'echo'> Beep bit = $echo(A\bar{D} + \bar{B}D + \bar{A}C + B\bar{C})$

From fig 2.10 >WR = $(\bar{A})(\bar{B}(\bar{C})(\bar{D})(\bar{E})$

> WR = (ABCDE)

It is noticed that WR has decimal equivalent zero'. It is desired originally to be the first bit (pulse) or rather the synchronization bit.

WR can take the form

$$WR = \overline{A + B + C + D + E}$$

using De Morgan's Theorem. This reduces the hardware from AND with inverted inputs to simply a NOR gate. This forms fig.

From table 1 >L.E.D.#1 = $(A\ \overline{\underline{B\ C\ D)}\ E}\ e\underline{cho}$

From table 2 >L.E.D.#2 = (A B C) D E echo

From table 3 >L.E.D.#31 = $A\ B\ \overline{C\ D\ E\ echo}$

From table 4 >L.E.D.#32 = A B C D E echo

It is noticed that 'echo' is common to all L.E.D.s thus a decoder / demultiplexer will be a suitable hardware.

CONJECTURING THE SUITABLE CIRCUITS

A ripple counter is suitable for generating the five bit word ....A B C D E'. See figure 2.9.

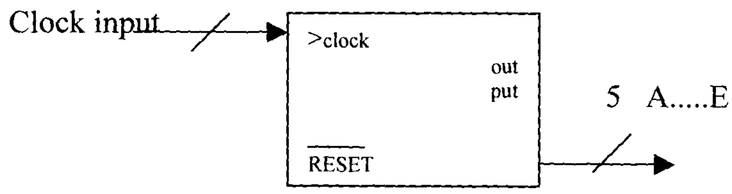


Fig ..2.9. 5-Bit Ripple Counter

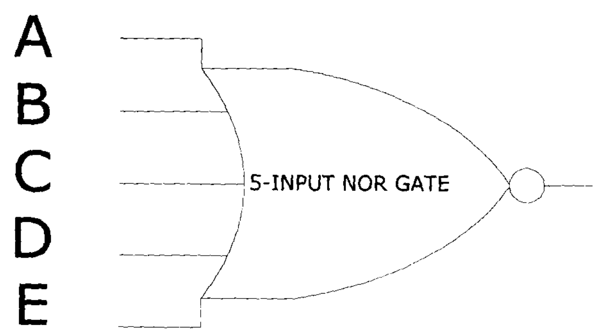


Fig 2.10 ; 5-input NOR gate.

CHAPTER THREE

3.1 CONSTRUCTION

This part of the work is tedious and requires good technical skill and time. It starts with the following steps.

1. parts selection
2. parts acquisition
3. Modular testing (bread boarding)
4. Adjusting circuit parameters if needful
5. P. C. B. layout planning for module transfer.
6. Circuit transfer.
7. Testing the transferred circuit and trouble shooting
8. Casing.

3.1.1 PARTS SELECTION

A lot of research is required where by for one to be able to make a good choice of component he must have enough option. Options only grow when research works is properly done.

Why CMOS ? Solid state electronic devices are made of silicon as major substrate but the way or phenomenon of manufacture varies. J – FET is never 100% equal to MOSFET while BJTis not even 60% close to the formers. The electrical power spent in each device above varies and is governed by;

I ; 1. The device power requirements and limits.

II ; 2 this design.

Since it is discovered that MOSFETs are voltage controlled and taste virtually negligible or no gate driving current they become mascots in switching like logic.

The complimentary MOSFET logic family takes least operating power. CMOS takes no quiescent currents, and tats about 1. 3 m A at 10 v supply when dynamic (snitching) at 1 MH_Z. CMOS has maximum switching goes of up to 5 MH_Z

Table ... 9; Velocities Of Ultrasound In Different Media

Medium /Metal/oil/air	Velocity (inchx10^5/ second)				Wavelength λ_L(inch)		
	V_a	V_l	V_T	V_R	1mc	2.25mc	5mc
Aluminum 2 SO	2.01	2.50	1.21	6.77	0.250	0.111	0.050
Aluminum 17 ST	2.00	2.46	1.22	1.10	0.246	0.109	0.049
Brass	1.40	1.70	0.85	0.77	0.170	0.075	0.034
Bronze, Phosphor (5%)	1.35	1.39	0.88	0.79	0.139	0.062	0.028
Copper	1.39	1.82	0.84	0.76	0.182	0.081	0.036
Lead, pure	0.47	0.85	0.28	0.25	0.085	0.038	0.017
Lead, Antimony (6%)	0.54	0.85	0.32	0.29	0.085	0.038	0.017
Steel (1080)	2.02	2.33	1.25	1.10	0.233	0.104	0.047
Stainless 410	1.98	2.91	1.18	1.06	0.291	0.129	0.058
Air	-- --	0.13	-- --	-- --	0.013	0.006	0.003
Water	-- --	0.59	-- --	-- --	0.059	0.026	0.010

Using length, l = 25.4 $x10^{-3}$ m, V= λf where 'λ'is the wave length of the ultrasound within medium if is the frequency of the wave and f = 1/T(T = period), an average velocity of 4709.644 m/s was chosen. Testing a 1 dm3 by 1 dm3 by 1 dm3 cube; One way travel takes 0.1m which will tale 2.123 10^{-5} seconds to cover. This leads to an ultrasound of 47. 0 69 10 3 Hertz. If you require receiving echo from the sending side of piece then the distance doubles and this frequency halves to give 23. 5 kH_Z. Since the time is divided into 32 parts the former frequency will require 32x 47 x 10 3 H_Z for the ripple counter. This thus maters the oscillator have a maximum clock of 1. 504 MH_Z. Fortunately, 2MH_Z can be got by the most available PLL (VCO inside) Since various frequencies are required.

The PLL chosen is MN/MC 4046B, which one can have, access to the"VCO in" in pin 9 and "VCO out" from pin 4, which some other PLL may not.

The 4046 B can give out frequency of from 0.2 HZ to 2MHz depending on external circuit parameters, which are

1. RT: This is the programming resistor that finds its places in the function > -(1/RT) (1/CT) Vin dt = $V_{triangle}$. $V_{triangls}$ is an internal voltage ramp type which the frequency is computed by the 4046 chip. It goes from pin 11 to Vss. CT: This is the integrators' capacitor also finding places in this equation mentioned in I above. It is connected between pins 6 and 7.

2. Vi This is the input voltage to the VCO inside the PLL chip this is accessed through pin 9 of the package. The out put frequency of the VCO is approximated to a mathematical model as out = $(K/(R_T C_T)$ (Vi –VB) where 'k' is a constant that varies slightly with supply (Vdd) voltage. VB is a voltage below which osculation is impossible.
3. Supply conditions: this chip requires little running current but with varying voltage. Switching is sharper and fester with increase in Vdd (supply voltage) but not beyond +15 v. 2MHz max output frequency is difficult to get with Vdd below + 10v.

3.12 P.C.B. LAYOUT PLANNING

To ensure easy application of ultrasound beams the entire unit has to be handy. This allows for mobility and accessibility to hidden corners of the test piece especially when it is larger than the test man. A compact circuit is required.

3.1.3 MATERIALS USED

The items secured for the circuits are as follows;

(a)	MC 4002B (1-unit)	(b)	MC 4040B (1-unit)
(c)	MC4046B (1-unit)	(d)	MC 4069B (1-unit)
(e)	MN 4081B (1-unit)	(f)	MN 4078B (1-unit)
(g)	MN 4502B (1-unit)	(h)	MN 4555B (1-unit)
(i)	MN 4514B (2-units)	(j)	TL 074 (1-unit)
(k)	HA 17555 (1-unit)	(l)	Red L.E.D (32-units)
(m)	Thomb Switch (2-units)	(n)	copper stripped fiber board (2-units)
(o)	Head phone jack (1-unit)	(p)	P.C Game port connector (3-units)
(q)	Thin 20-pin I.C base(1-unit)	(r)	24-pin I.C base (2-units)
(s)	14-pin I.C base (5-units)	(t)	16-pin I.C base (5-units)
(u)	8-pin I.C base (1-unit)	(v)	9 volts dry battery (1-unit)

3.2 CASING

It was cased in a 5 ½` by 4 ½` by 4` plywood cuboid. This size of case is chosen for portability and ease in assembly. The main board is a cupper stripped fiber measuring 15 centimeters by 6 centimeters. Included in the case is the daughter board that houses the analogue circuits, a small nine volts dry battery, connecting wires and the display board, which houses 32 L.E.D.s, power switch and the buzzer option switch.

CHAPTER FOUR

4.1 CONCLUSION

The objective of this project work has been achieved to a large extent viz. to construct a simple inexpensive device, which could be used for the non-destructive test of metal for internal conditions, and to come up with recommendations that will aid further studies on this subject by students willing to take up the challenge.

Audio and visual techniques were used for the identification of faults, thus eliminating the necessity of using an oscilloscope to visualize the defect, which is usually very expensive. Also such a device will require skilled personnel to operate.

However, little problems were encountered such as the unavailability of custom-made *Piezo* transducer that suite the design specifications, hence affecting the efficiency of the device. The unavailability of certain gates in I.C form led to improvisation of discrete components.

4.2 RECOMMENDATIONS

Considering the strategic importance of ultrasonic testing in manufacturing industries, and the successes and limitations so far recorded on the project work, I wish to make the following recommendations:

i. Better and custom-made *Piezo*- electric transducer that can accommodate higher frequency signals should be employed

ii. Other methods of visualizing defects such as using the computer by providing suitable interface hard ware should be considered in future developments.

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…TIONS …TER					En.	OUTPUTS — LIGH EMMITTING DIODE BAR OUTPUT																																Auxiliary o/p	
			D	E	En	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	En	WR
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
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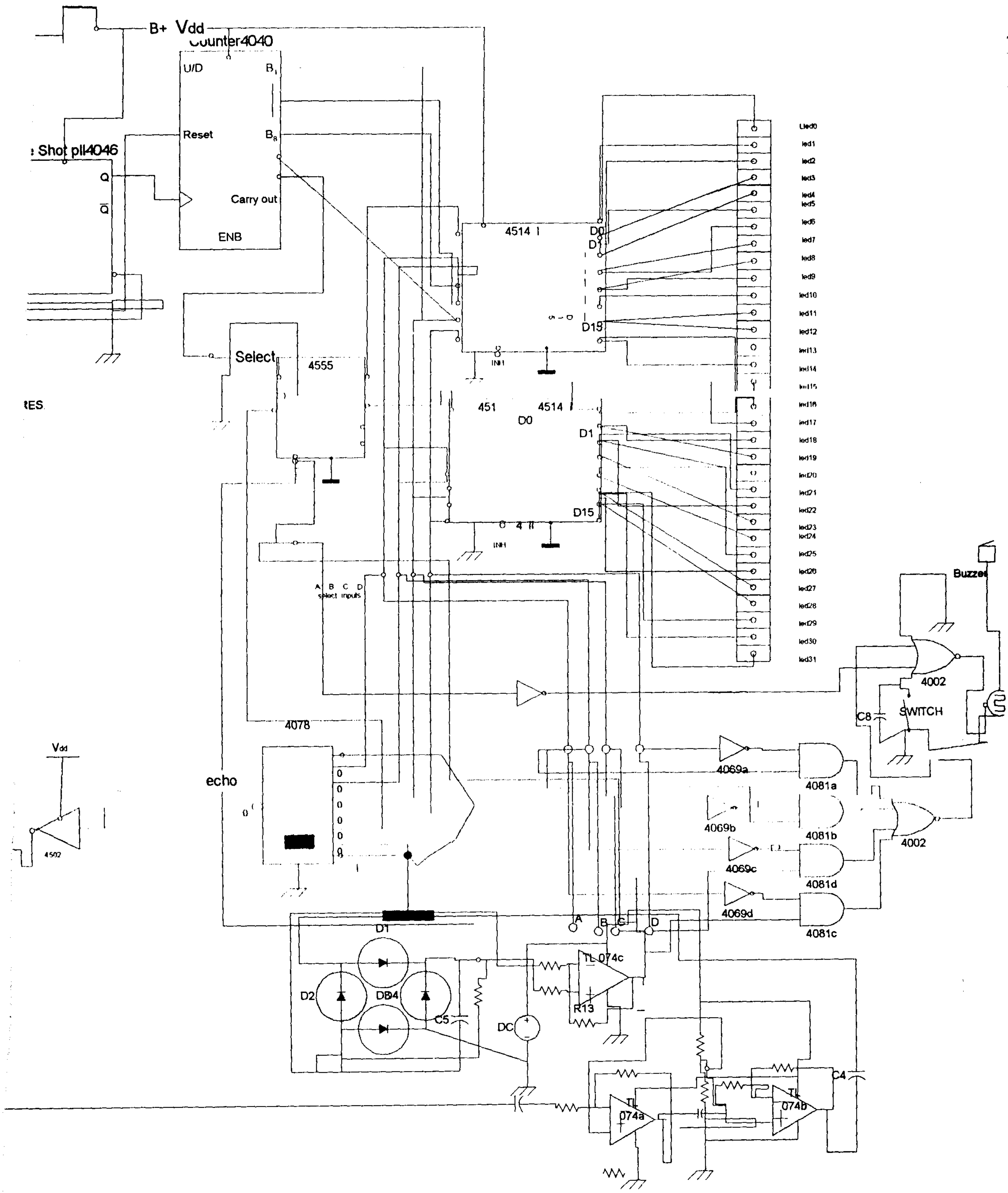
Table 2.0 State/truth Table



ULTRASONIC FLAW DETECTOR SCHEMATICDIAGRAM