A PROJECT REPORT

ON

DESIGN AND CONSTRUCTION

OF

A SIMPLE DIGITAL AIR TEMPERATURE READING DEVICE

BY

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DEPARTMENT OF ELECTRICAL/
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FEDERAL UNIVERSITY OF TECHNOLOGY,
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SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR

THE DEGREE OF BACHELOR OF ENGINEERING

(ELECTRICAL/COMPUTERS)

APRIL 1994.

CERTIFICATION

I hereby certify that this work was carried out by MR. ADEJUMO, AMOS ENITAN OLUWAROTIMI of the department of ELECTRICAL/COMPUTERS ENGINEERING, Federal University of Technology, Minna, Niger State, Nigeria.

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PROFF. S.O. AJOSE

DATE:.................

DATE:...................

....
EXTERNAL EXAMINER

DATE:..................

DEDICATION

This project is dedicated to the Lord, JESUS, my beloved parents, MRS. F.A. BANKOLE and MR. F.A. ADEJUMO, my respected guardians MR. J.O. IDOWU and CHIEF J.O.A. BANKOLE, and to my able beloved fiancee Sister OLUWAFUNMIBI ADEYEMO.

ACKNOWLEDGEMENT

My humble and honest gratitude goes to my loving God, His only son JESUS for His divine provisions, protection and guidance throughout the cause of my study.

My report will be incomplete without mentioning some respected people whose cooperation and contributions were seriously felt in the completion of this project. My heartfelt appreciation goes to my preject supervisor, MR. L.M. AIYEPADA, for his faithful efforts in making this project a success. Also my profound thanks goes to my Head of Department, the entire staff (lecturers) of the department and MR. ABIFARIN of mechanical department, for their supports and memorable contribution.

My heartfelt gratitudes surely goes to my able mother for her motherly love and kindness in my life. I thank God for giving me a faithful mother like you are. I love you, mom for many things.

My special indebtedness goes to my able guardians, Chief J.O. Bankole, Mr. J.O. Idowu, Mrs. O. Oladejo for all their supports. I also appreciates the love of these people in my life. Mrs. L.S. Ahmed, the Registrar, Federal University of Technology, Minna, Miss Toyin Adejumo, Temitope Adejumo, Segun Idowu and Sister Nike (Mama Biodun), just to mention but few.

My deep regards and appreciations goes to my able fiancee Sister Oluwafunmibi Adeyemo for her love, kindness

and spiritual supports showing in my life.

Finally, LORD, I say I love you, praise you and worship you for everything you are to me.

´Itan ´94.

ABSTRACT

The project dwells on air temperature reading device which could be read simply through the number display at the seven-segment LED.

The technique employ.ed in the digital air temperature reading device was based on air temperature sensor circuit using sensor diode, as transducer. The circuit will conveniently convert the temperature signals into electrical signals. The sensor employed in this project is the sensor diode (a forward biased silicon diode) which is supplied with a constant current from the transistor, so as the temperature changes, the voltage across the diode will drop.

The system was designed, constructed and tested which could be used in many applications. It could be use in weather forecasting, to know the temperature of the region, in Agricultural purpose to just mention but few.

TABLE OF CONTENTS

CHAPTER ONE

1.0. INTRODUCTION

The project topic is "THE DESIGN AND CONSTRUCTION OF A SIMPLE DIGITAL AIR TEMPERATURE READING DEVICE". It is able to sense the air temperature of the surrounding and display the value (result) in degree centigrade after conversion by the use of analogue to digital converter.

Although there exist various ways to measuring the temperature of surrounding and some physical properties. But trying to make my own contribution, I choose this project, having the objective to have a break through of the anomalies results got from other existing temperature measuring device e.g. clinical thermometer.

Taking Federal University of Technology, Minna as a case study, we need this measuring device in our various laboratories, to measure the air temperature, for example, in chemistry labs, biology labs, even in the University clinic to mention but few.

The working temperature environment is needful in most, if not all, cases. This instrument should be mount-up in strategic places for clear feasibility of temperature reading.

The design circuitory consist mainly of three basic sections. These sections are air temperature sensing circuit section, conversion section, and display section.

Figure 1 explain the basic flow of the design of this project, which are in block diagram.

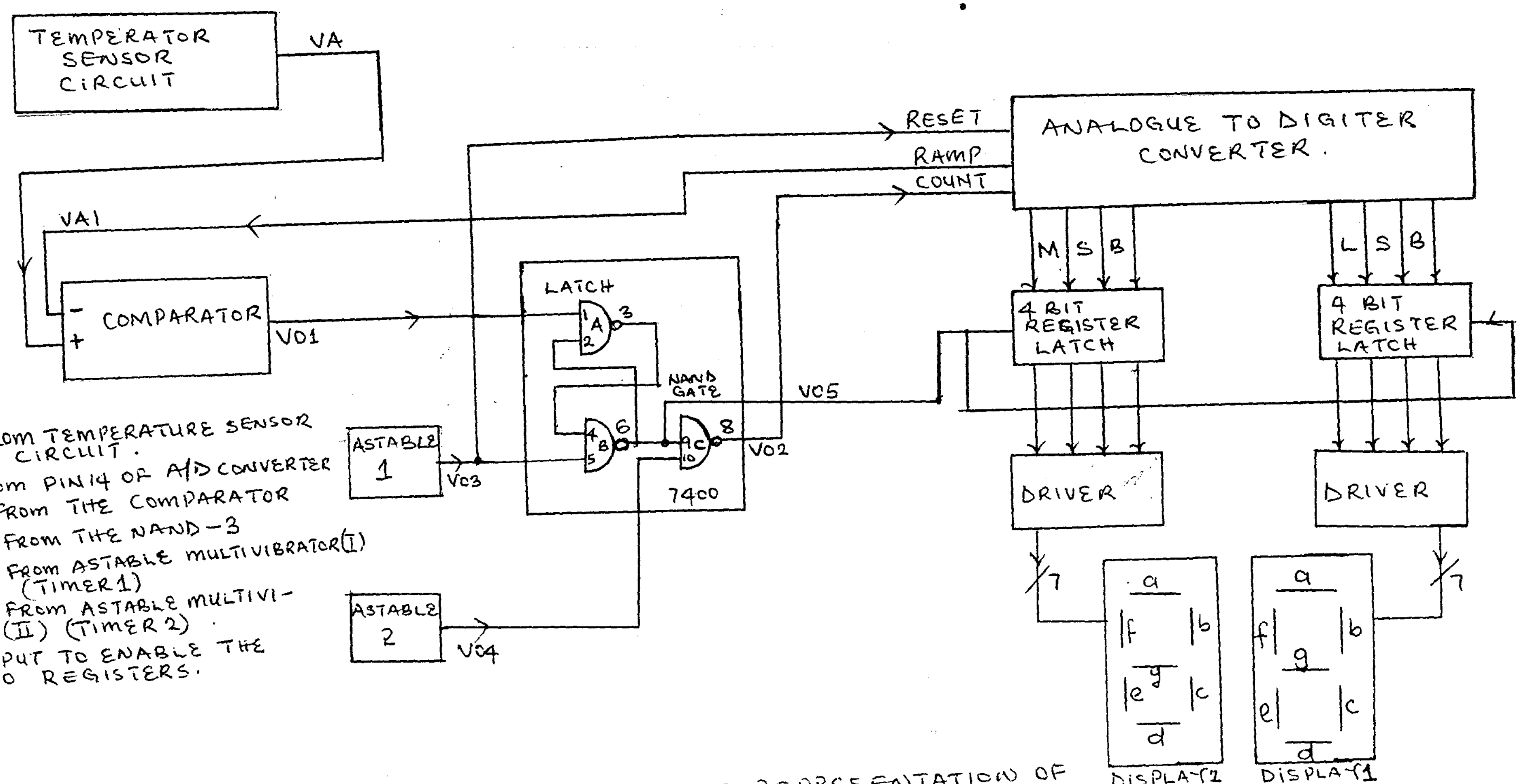
The air temperature sensor circuit uses a forward biased silicon diode which is supplied with a constant current from the transistor Tr. This circuit generage an analogue signal output, VA. whis is fed into comparator 1, together with VA1 (RAMP), an analogue output from the A/D converter. The comparator 1 has its output to be VO1.

A NAND GATE (7400) was employed, which contain four nand gate. Gate A and gate B was cascaded to give a latch (bistable). This latch has two inputs, in which VO1 and VO3 were fed into. Gate C of 7400 which was employed as a normal nand gate, has two inputs which was engaged with the output from gate B and VO4. The overall output of this gates comes from the output of gate C, VO2 and was fed into COUNTPIN of the A/D converter.

Also the output VO3 from Astable 1 was fed into the RESET PIN of the A/D converter. The A/D converter produces 8-bits digital output, which was fed into two 4-bit latch registers. One of the 4-bits latch register receives the 4 bits (low significant bit) and the second receives the other 4-bits (most significant bit). This two 4-bits latch register could be RESET by VO5.

The outputs from the latch registers is then fed into the inputs of the two Drivers accordingly. Each of the Drivers has seven outputs which are fed into two seperate display (seven segment display, LED).

The details of figure 1 shall be discussed in full in chapter two.



VA ⇒ OUTPUT FROM TEMPERATURE SENSOR CIRCUIT.

VA1 ⇒ OUTPUT FROM PIN14 OF A/D CONVERTER

VO1 ⇒ OUTPUT FROM THE COMPARATOR

VO2 ⇒ OUTPUT FROM THE NAND-3

VO3 ⇒ OUTPUT FROM ASTABLE MULTIVIBRATOR(I) (TIMER1)

VO4 ⇒ OUTPUT FROM ASTABLE MULTIVIBRATOR(II) (TIMER 2).

VO5 ⇒ AN OUTPUT TO ENABLE THE TWO REGISTERS.

FIG. 1 – BLOCK DIAGRAM REPRESENTATION OF A SIMPLE DIGITAL AIR TEMPERATURE READING DEVICES.

1.1. LITERATURE REVIEW

Conversion of one form of energy into another is easily done by mean of an element called transducer. Active & Passive are two basic types of transducers. The active, also called self generation, transducer converts energy directly from one state to another, without the need for an external power source, or excitation. An example of this is a termocouple which gives an electrical signal output when one of its ends is heated. A passive transducer, on the other hand, does not convert energy directly but controls the energy or excitation, which comes from another source.

If one classifies energy into six different types then Fig. 1·1. gives the combinations of input or measurand, output and excitation for any transducer. This fully indicates that there are available different types of transducer.

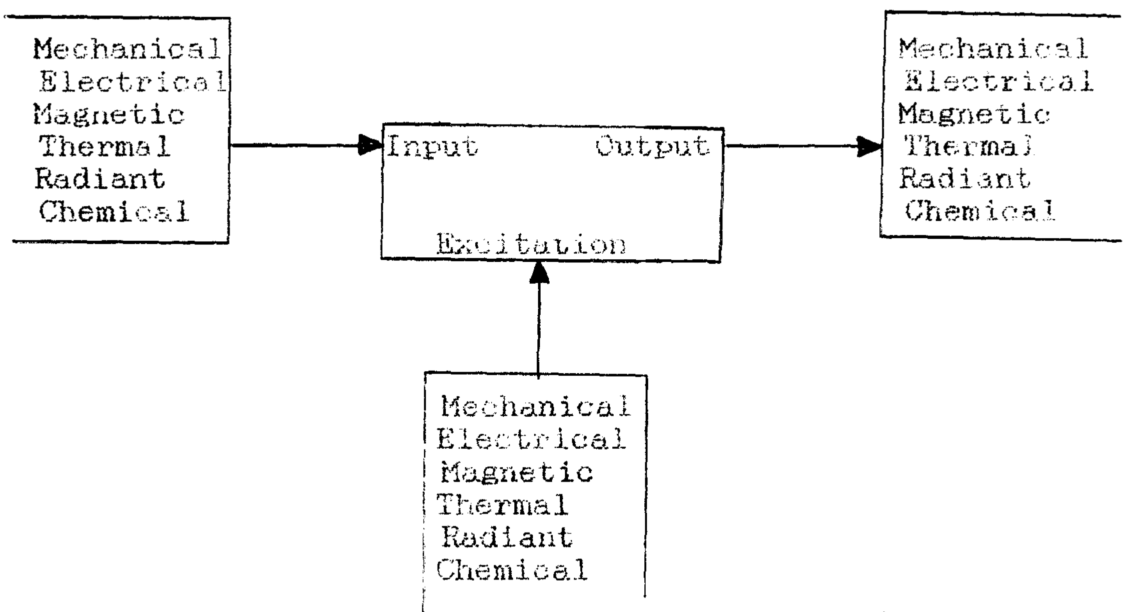
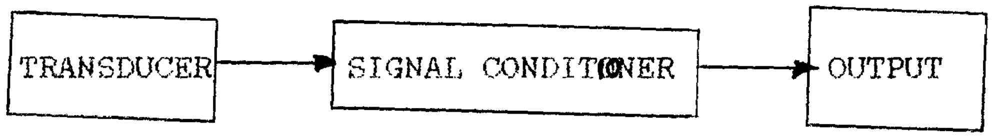


Figure 1:1

Transducer Combinations.

Considering in this project is a temperature sensing circuit which is very sensitive to air temperature. In this the output and excitation are both electrical.

A transducer (a circuit which converts one form of energy into another) is usually the first element in a measurement system, as shown in figure 1.2 below.



simplified measurement system using a transducing figure 1.2 circuit.

The signal conditioner modifies the signal from the transducer, such as by ware shaping (amplification) to suit the requirements of the output device. This device may be an indicator or storage medium.

Generally there are three considerations in the selection of energy conversion circult (element). These includes, the required characteristics, the type of transducer technology and the force-swimming element used.

Several parameters is used to be considered when selecting a transducer for an application. The sensitivity of the transducer the output, usually in volts, which it produces for give input signal and excitation level. The resolution is the smallest quantity which can be measured, and the repeatability indicates how closely two measurements of the same value correspond to each other. Other things to be consider in the characteristics of transducer includes accuracy, environmental effect, frequency response, dynamic characteristics and the transducer should also be able to resist noise, which is usually all signals apart from the input.

Principally are three types of temperature measurement devices which includes resistance temperature detectors, thermocouples and themistors. In addition to the above three mentioned are other techniques for temperature measurement which are, quartz crystals, radiation **pyrometers** and semiconductor sensor.

Temperature measurement transducer (circuit) may be surfaced mounted or immersed in the fluid being measured. It is important that the measurement device does not affect the temperature of the surface, such as by conducting heat away from it. Often they are protected from environment by a case.

The project employed semi conductor temperature sensors which usually detect the change in the base - either voltage or a transistor with temperature, which gives a temperature sensitive voltage of about 2.1mV/c. The base either voltage Vbe according to

$$Vbe = \frac{KT}{q} \ln(I_c I_s^{-1})$$

K implies Boltzmam constant, T is the temperature in Kelvin, q is the electron charge and Ic and Is are collector current and reverse saturation current of the transistor respectively. Semi conductor sensors have an accuracy of about 12% over the range -40 to +150oc.

CHAPTER TWO – DESIGN OF COMPONENTS

2.0. INTRODUCTION

A block diagram representation of the simple digital air temperature reading device is as shown in figure 1. Each block represents a stage in the whole circuit arrangement. There are TEN stages; the comparator I, Temperature sensor circuit, Astable I, Astable II, latch, Nand gate, Analogue to digital converter, Bistable latch registers, drivers ad display state. The stages are arranged in tendom such that the output of one stage serves as input to the other stages. This chapter covers the design specification of each stage.

2.1. VOLGATE COMPARATOR

The voltage comparator is a device which can be used to compare the magnitude of two voltages. It is a digital device since it produces only two distinguishable output states, (LOW OR HIGH). The heart of the comperator is operational amplifier. See figure 2.1.

Let the VA, be the Voltage output from the temperature sensor circuit be fed into non-inverting input (pin 7) and VA1, the analogue output (pin 14) from the analogue to digital convertor be applied to the inverting input (pin 6) of the comparator.

VA1 voltage is constantly being compared with a voltage VA being produced by a temperature sensing network. As long as the VA1, analogue voltage produce by the analogue to digital converter remains below the input analogue voltage

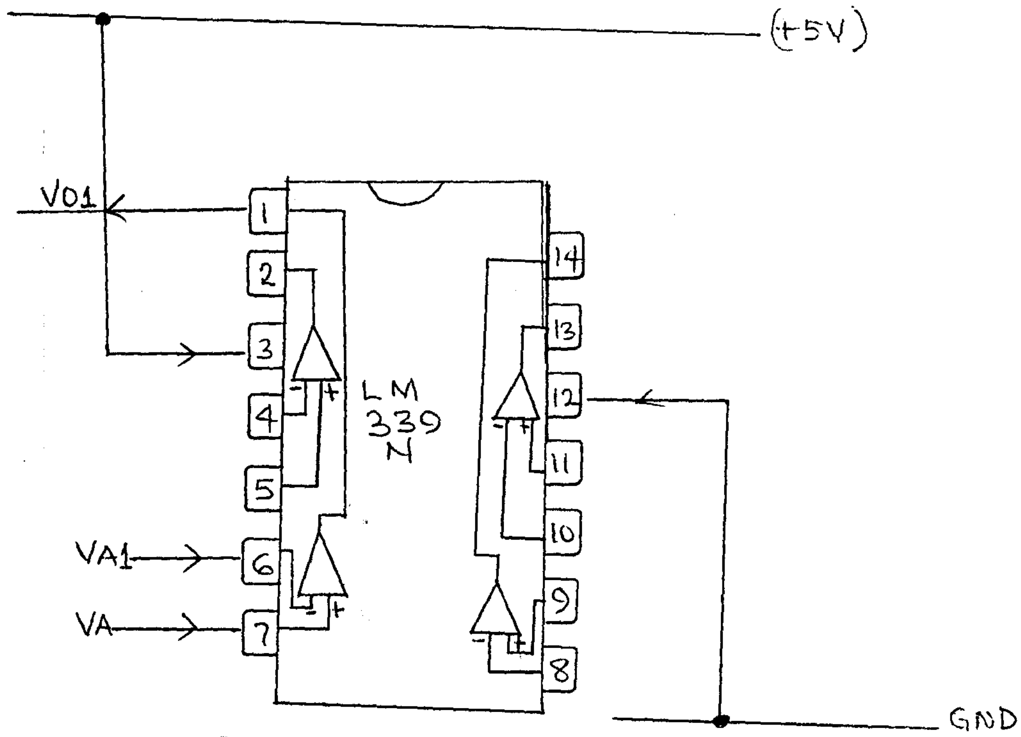


FIG. 2.1 — COMPARATOR
VA ⇒ OUTPUT FROM TEMPERATURE SENSOR CIRCUIT.
VA1 ⇒ OUTPUT FROM PIN14 OF A/D CONVERTER.
VO1 ⇒ OUTPUT FROM THE COMPARATOR.

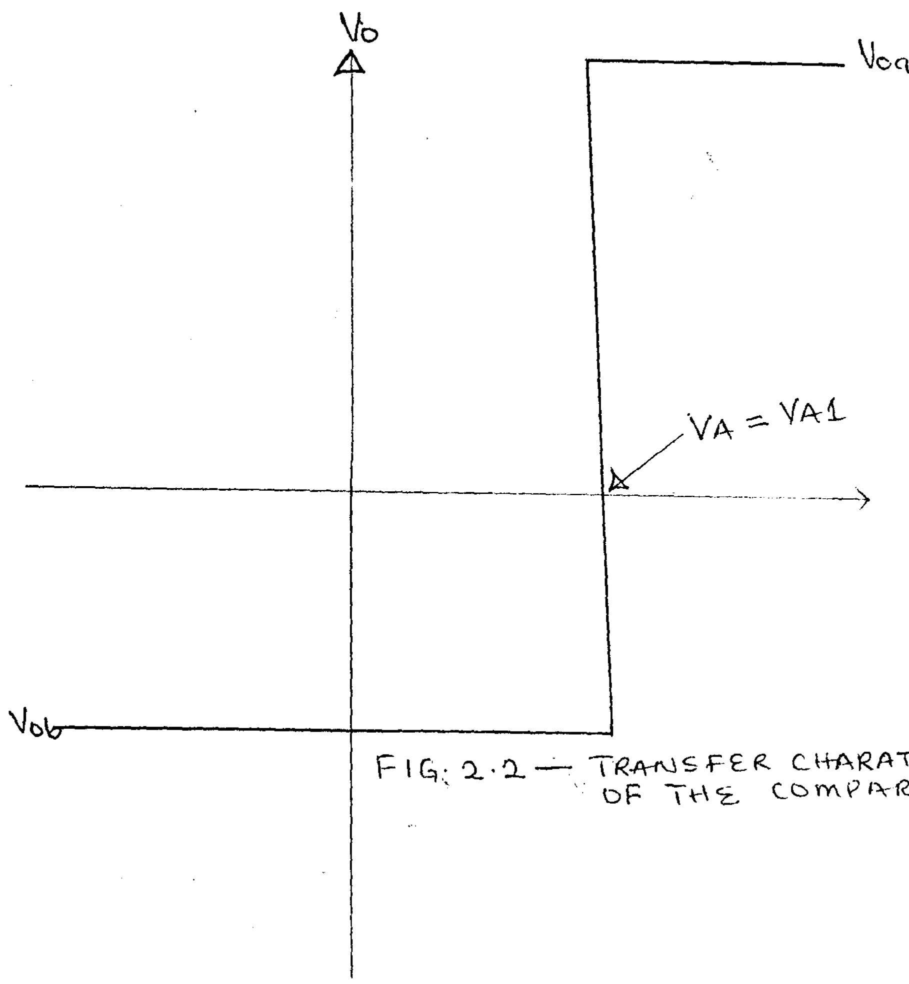


FIG. 2.2 — TRANSFER CHARATERISTICS OF THE COMPARATORS

produced by the temperature sensor, then the putput of this comparator I is HIGH, VO1. See gigure 2.1. But when the VA1, analogue voltage produce by th analogue to digital converter exceeds VA, input analogue voltage produced by the temperature sension, then the output of this comparator is LOW. VO1.

Thus the output voltage, Vo.

Vo = Ao (VA - VA1)

Ao - Is the differential gain.

Figure 2.2 shown, is the transfer characteristic of the comparator.

2.2. ASTABLE MULTIVIBRATOR I

This is a type of logic circuit that switches back and forth (oscillates) between two unstable output states. It is use to provice clock signals for the BCD counter. It is also called Free-running multivibrator 555 timer IC is the heart of the astable multivibrator. The 555 times is connected as an astable as shown in figure 2.3.

Immediately the power is on, the capacitor C1 charges through R1 and R2 until it reaches 2/3 vcc, then the time´s output goes LOW, then the capacitor start to discharge, when it discharges to below 1/3 vcc, the timer´s output goes HIGH after a time t1 determined by R1 and C1. Then, the capacitor C1 charges through R1 and R2 from 1/3 Vcc until it reaches 2/3 Vcc after which the output return LOW, after a time t2 determined by R1, R2 and C1, and the cycle is repeated continuously resulting into the generaion of train

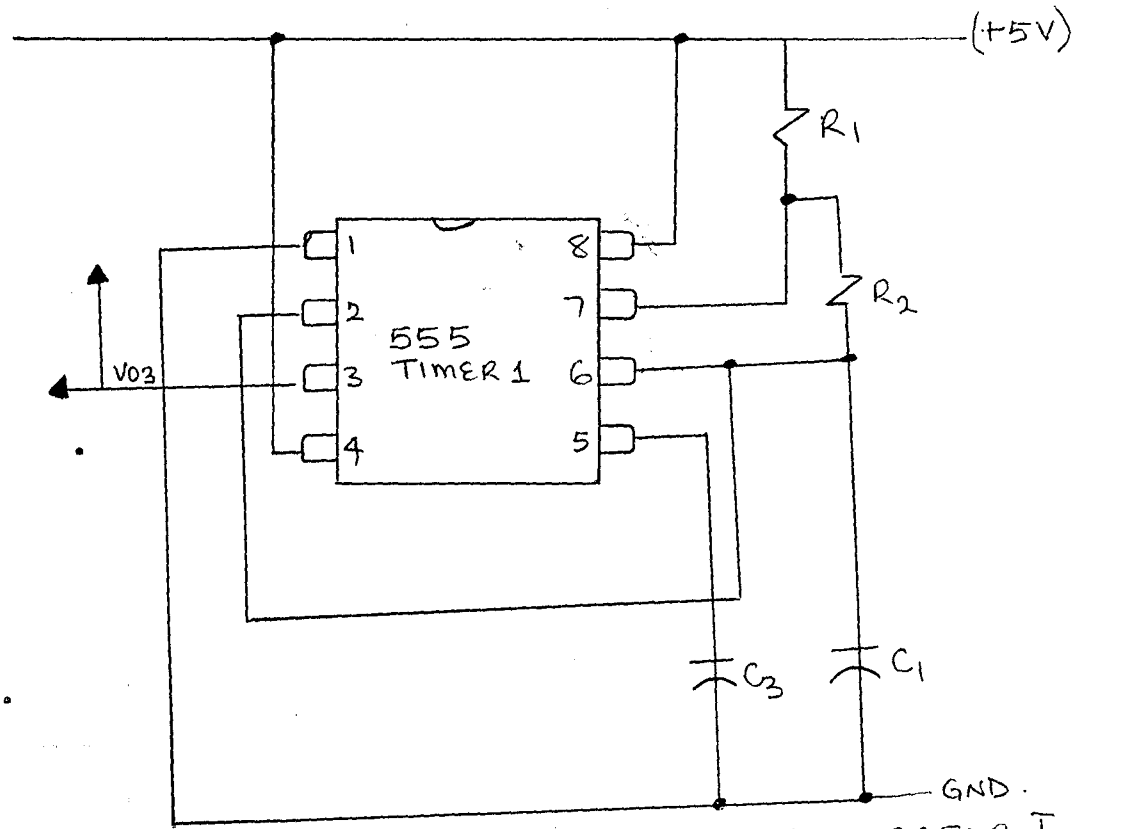


FIG. 2.3 — ASTABLE MULTIVIBRATOR I
R1 = 2.2MΩ; R2 = 1KΩ; C1 = 10μF;
C3 = 10nF.
V03 — OUTPUT FROM ASTABLE MULTIVIBRATOR (I) (TIMER 1)

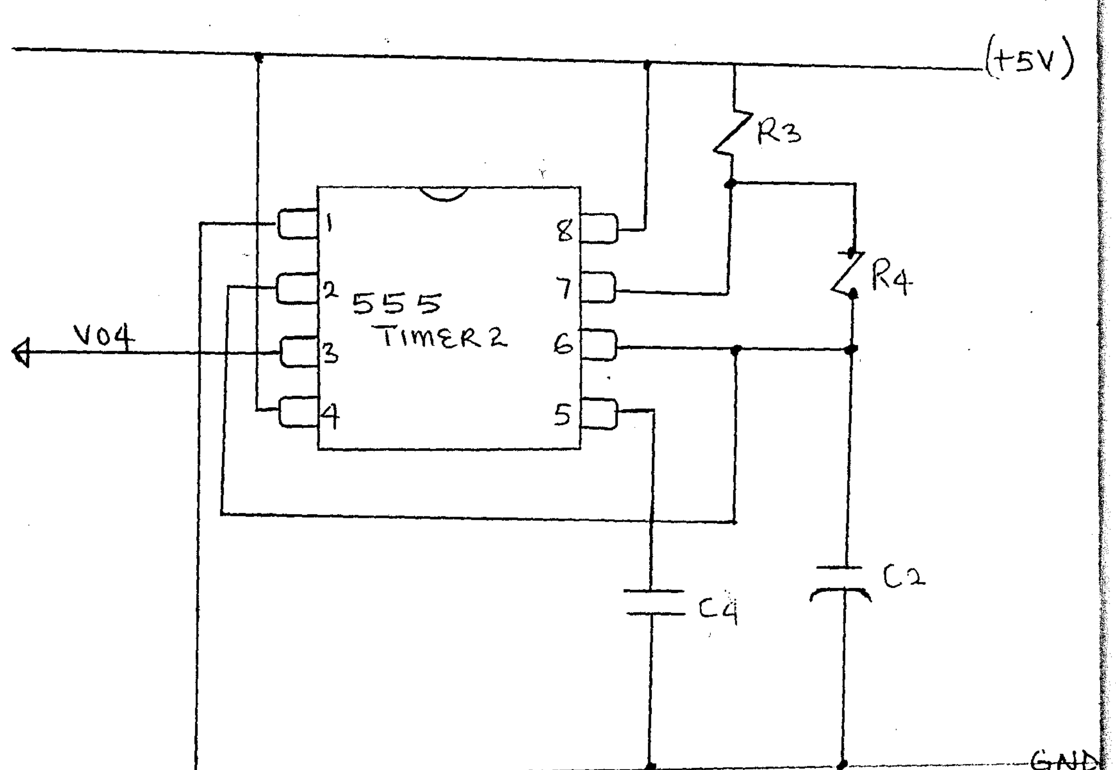


FIG. 2.4 — ASTABLE MULTIVIBRATOR II
R3 = 2.2KΩ; R4 = 22KΩ.
C2 = 470nF; C4 = 10nF.
V04 — OUTPUT FROM ASTABLE MULTIVIBRATOR (II) (TIMER II)

of pulses as shown in figure A1.2.

2.3. DESIGN CALCULATION

FOR ASTABLE MULTIVIBRATION I

The frequency of oscillation (F1) is given by the expression

$$F1 = \frac{1.44}{(R1 + 2R2)\ C1} \quad ..... \text{ eq1}$$

Duty cycle is given as D1

$$D1 = \frac{R1 + R2}{R1 + 2Rs} \quad ...... \text{ eq2}$$

For D1 = 99.95%

= 0.9995

then $D1 = 0.9995 = \frac{R1 + R2}{(R1 + 2R2)}$

0.0091 R2 = 0.000454R1

R2 = 0.0004545R1

Taking R2 = 1KΩ (Designed value)

The $R1 = \frac{R2}{0.0004545}$

$= \frac{1000}{0.0004545}$

= 2200018.18Ω

= 2.2 MΩ (Designed value)

The frequency generated by this astable multivibrator I is given as F1.

$$F1 = \frac{1.44}{(R1 + 2R2)\ C1}$$

R2 = 1KΩ (Designed Value)

R1 = 2.2 MΩ (Designed Value)

also C1 = 10 μF = $10 * 10^{-6}$ F.

Then,

$$F1 = \frac{1.44}{[2.2M\Omega + 2(1K\Omega)] * 10 * 10^{-6}}$$

$$= \frac{1.44}{22.02}$$

$= 0.0654HZ.$

And period T,

$$T1 = \frac{1}{F1}$$

$= 15.25$ seconds.

The generated pulse from astable multivibrator I is output from V03, pins 3.

2.4. ASTABLE MULTIVIBRATOR II

This is the same as astable multivibrator I, escept that the designed value is different. The pulse generated by this astable multivibrator II is output from pin 3, Vo4.

See figure 2.4.

2.5. DESIGN CALCULATION FOR ASTABLE MULTIVIBRATOR ii

The frequency of oscillation (F2) is given by the expression.

$$F2 = \frac{1.44}{(R3+2R4)C2} \quad \ldots\ldots\ \text{eq.3}$$

Duty cycle is given as D2

$$D2 = \frac{R3 + R4}{R3 + 2R4} \quad \ldots\ldots\ \text{eq.4}$$

For $D2 = 52.38\% = 0.5238$

Then $D2 = 0.5238 = \frac{R3 + R4}{R3 + 2R4}$

$0.5238\,(R3 + 2R4) = R3 + R4$

$0.04762\ R4 = 0.47619R3$

$R4 = 9.9998R3$

Selected R3 = 2.2KΩ (Designed Value)

Then

$$R4 = 9.9998 * (2.2K\Omega)$$

$$R4 = 21999.56\ \Omega$$

$$R4 = 22K\Omega \text{ (Designed value)}.$$

The frequency generated by this astable multivibrator II is giver as, F2.

$$F2 = \frac{1.44}{(R3 + 2R4)\ C2}$$

$$\text{let } C1 = 470\ nf = 470 * 10^{-9}\ F$$

$$R3 = 2.2K\Omega \text{ (Designed Valued)}$$

$$R4 = 22K\Omega \text{ (Designed value)}$$

$$F2 = \frac{1.44}{[2.2K\Omega + (22K\Omega)2] * 470 * 10\ F}$$

$$F2 = \frac{1.44}{0.021714}$$

$$F2 = 66.32\ HZ.$$

And period, T2

$$T2 = \frac{1}{F2}$$

$$= 0.0151\ Sec.$$

$$= 15.1\ mS$$

2.6. NAND GATE LATCH

Two NAND gates are cross-coupled so that the output of NAND-1 is connected to one of the input NAND-2, and vice-versa.

Figure 2.5. show the connection of the Nand gate latch. The output of the Comparator 1, V01 was fed into pin

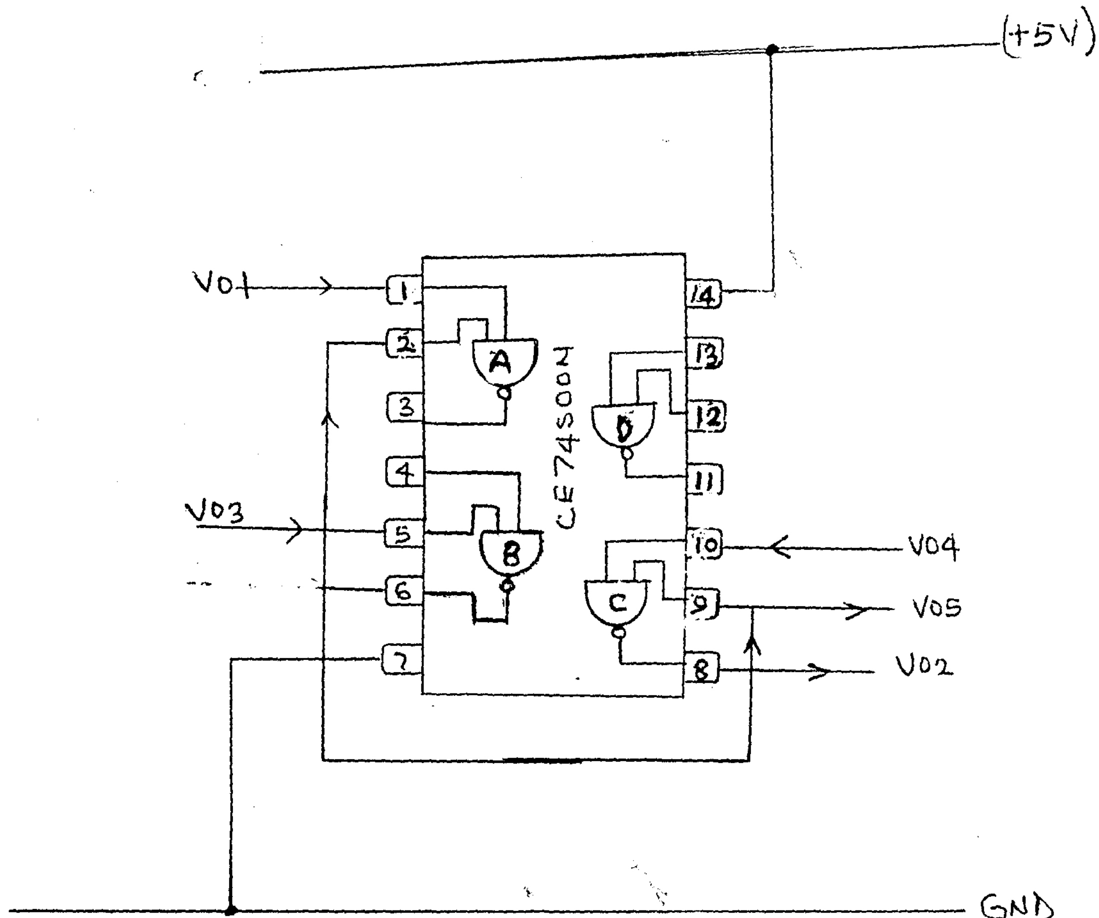


FIG. 2·5 — NAND GATES LOGIC CIRCUIT

A ⇒ NAND – 1
B ⇒ NAND – 2
C ⇒ NAND – 3
D ⇒ NAND – 4 (BUT NOT USED)

V02 – OUTPUT FROM THE NAND – 3
V04 – OUTPUT FROM ASTABLE MULTI-VIBRATOR(II) (TIMER 2)
V05 – AN OUTPUT TO ENABLE THE TWO REGISTERS.
V01 – OUTPUT FROM THE COMPARAT

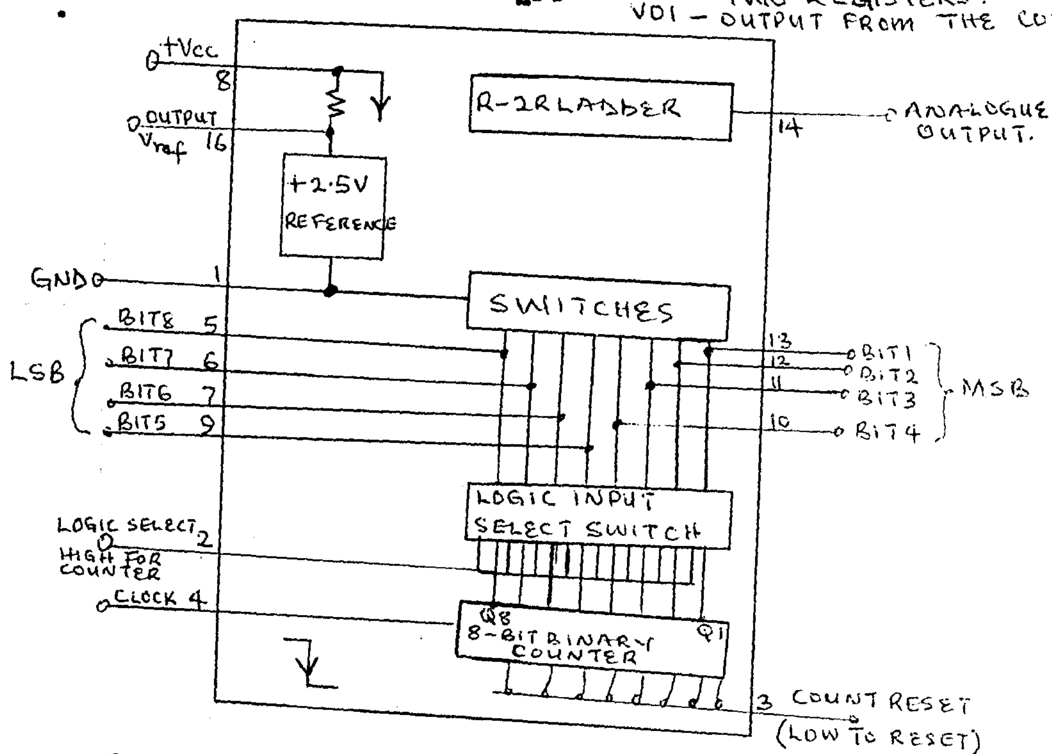


FIG. 2·6 — BLOCK DIAGRAM OF THE ZN425E DEVICE

1 of the NAND-1. Also the output of the astable multivvibrator I. V03, was fed into pin 5 of the NAND-2. The output of this two NAND gates connected together was feed into another NAND gate in the 7400 IC chip. Overall output from this chip is from pin 8 of NAND-3, Vo2, which was later fed into COUNT, pin 4 of the analogue to digital converter (ZN425E).

2.7. NAND GATE

It has briefly been discussed in 2.6. It is a normal Nand gate which take in two inputs. The two inputs are the output from the Nand gate latch, pin 9, and the output V04, from the astable multivibrator II. It has an output of pin 8, V02, which was fed into pin 4 of the A/D converter (ZN425E).

See figure 2.5..

2.8. ANALOGUE TO DIGITAL CONVERTER

Some circuit are available purely as ADC (analogue oto digital converter) circuits while others can have a dual function of providing ADC or DAC (Digital to analogue converter).

The ZN424E is an eight-bit dual mode ADC/DAC utilising an R-2R ladder network, an array of precision bipolar switches, an 8 bit binary counter and a 2.5V precision voltage reference all on a single monolithic chip. Figure

In the project, analogue to digital converter was created using ZN425E, a converter was created using a

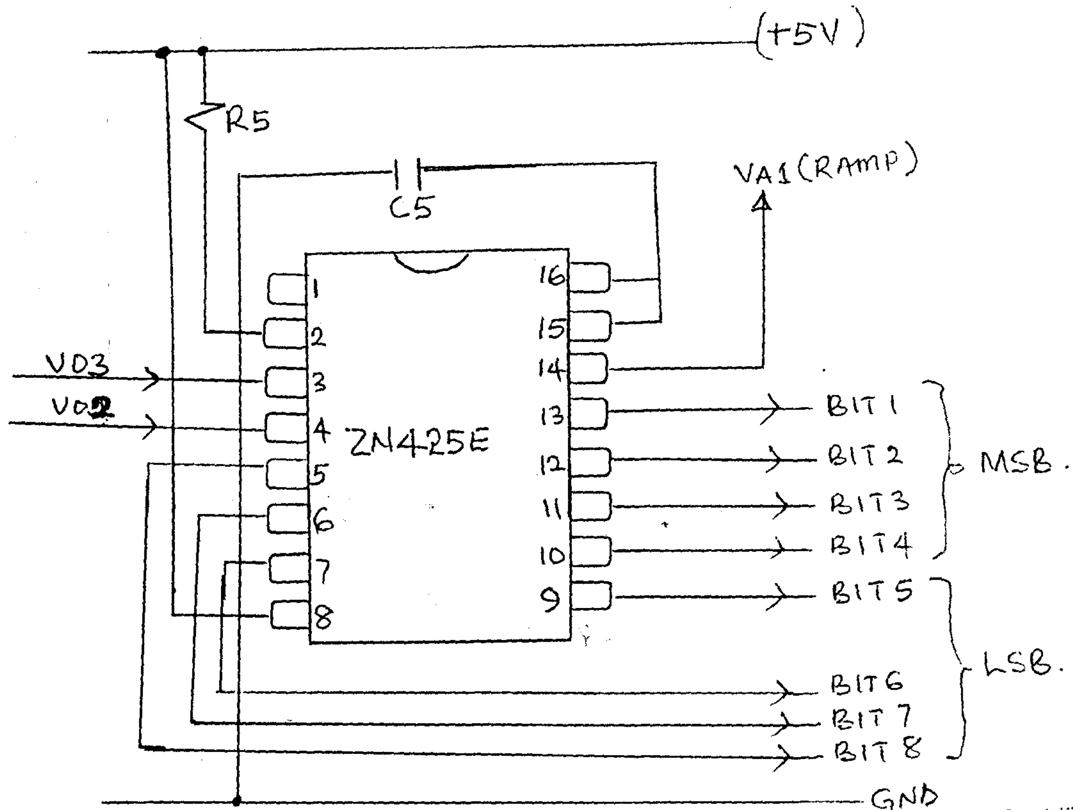


FIG. 2.7 — ANALOGUE TO DIGITER CONVERTER CIRCUIT

V03 — OUTPUT FROM ASTABLE MULTIVIBRATOR I

V02 — OUTPUT FROM THE NAND — 3.

VA1 — ANALOGUE OUTPUT FROM THE ZN425E WHICH IS COMPARED WITH VA

R5 = 1KΩ ; C5 = 0.22μF.

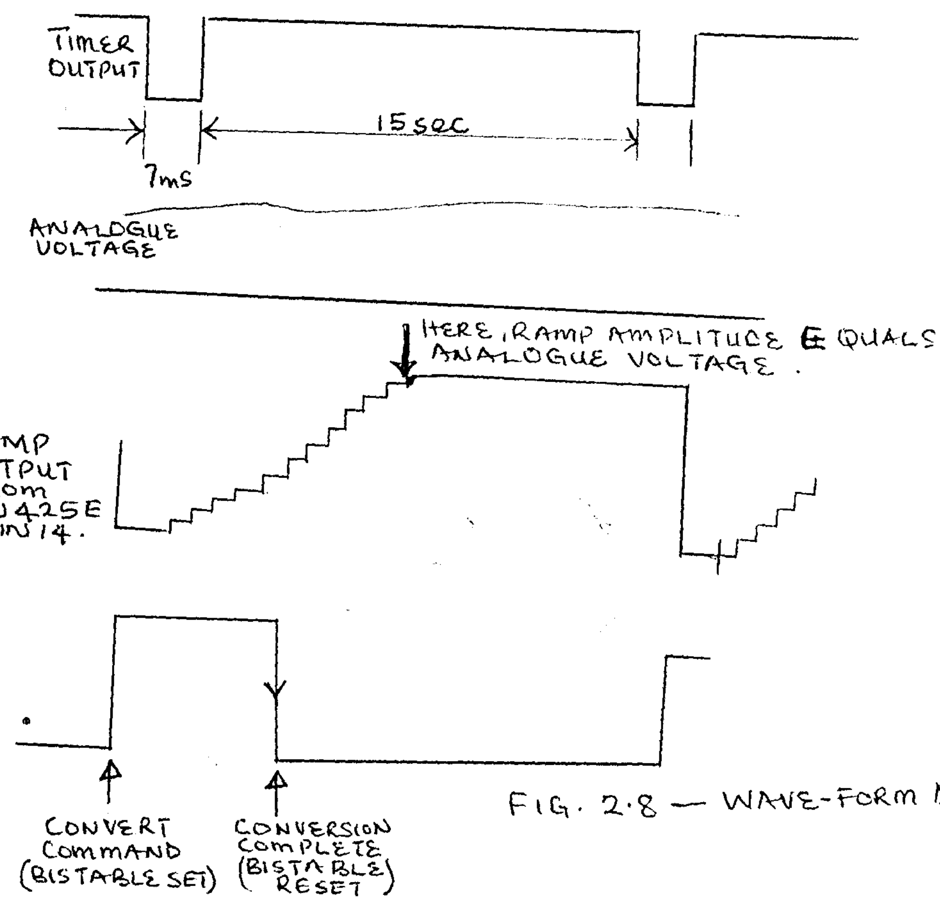


FIG. 2.8 — WAVE-FORM DIAGRAM

ZN425E, a comparator, LM 339 and some logic gates in 7400, 14 pins IC. The LM 339 comparator is a 14 pins IC chip which is operated by a single voltage source.

The action of this A/D converter circuit is controlled by the time (astable multivibrator I). The 15 second wait time between sampling is set by R1 and C1. The biasing of ZN425E is shown in figure 2.7 The operation is more easily understand by studying the waveform diagram in figure 2.8.

When the time output, VO3, goes LOW for a few milliseconds just after the main delay, the following actions take place.

(i) The control bistable is set. The output of NAND-2, pin 6, goes HIGH.

(ii) Status rises HIGH.

(iii) The internal counter in the ZN425 is reset and held.

At the end of the relatively short negative pulse from the timor, the reset is removed and clock pulses from VO4 (output of astable multivibrator II) pass through NAND-3 to the ZN425E. The 8-bit counter accumulates counts and inside ZN425E the state of the counter is converted by a resistive ladder network (R-2R type) in a ramp signal output at pin 14.

The ramp signal(analogue signal), VA1, which can have a maximum of 255 steps and a voltage level of 2.5V, is then compared with the analogue voltage from the temperature sensor circuit output, VA. When VA1 exceeds VA, then the comparator's output, VO1, goes low and reset the bistable

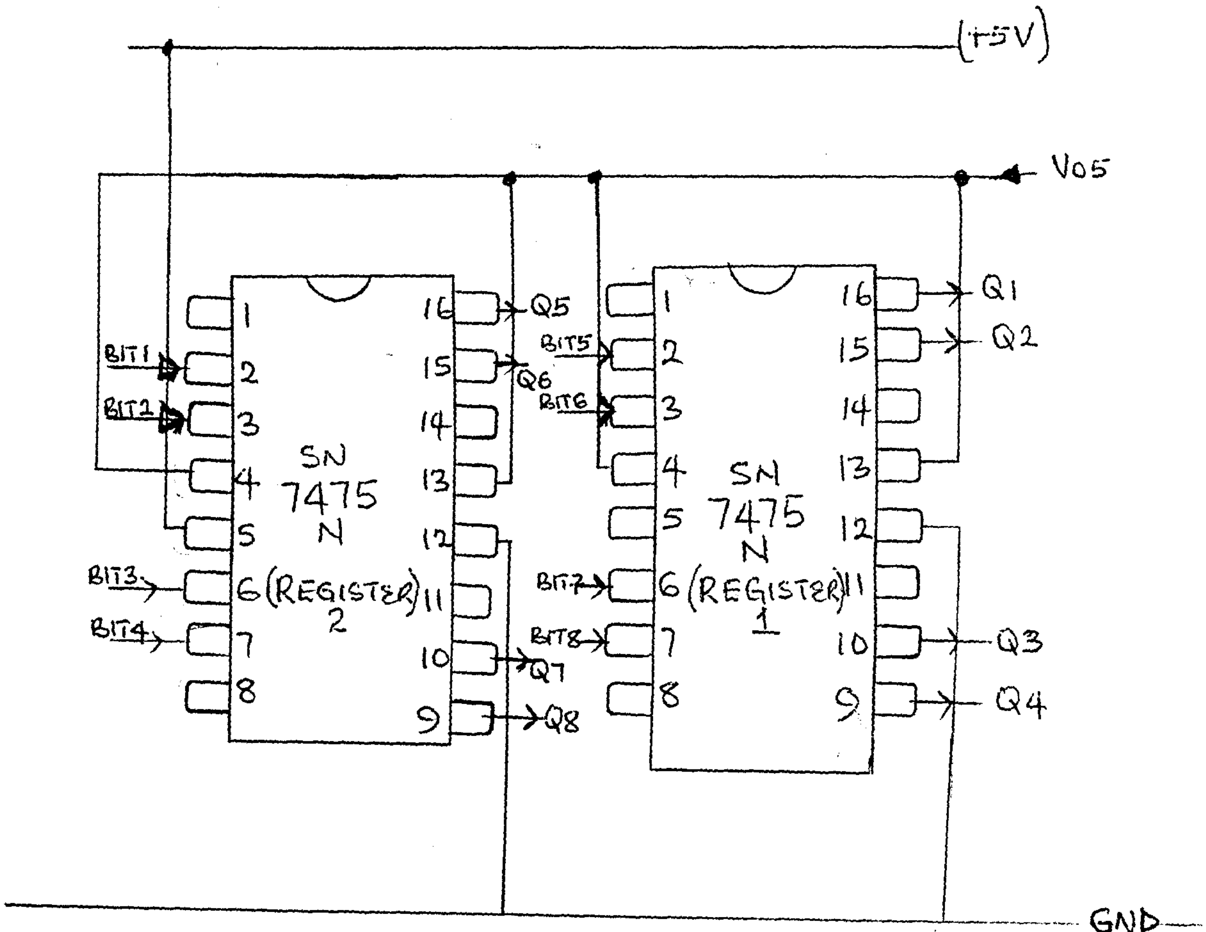


FIG. 2.9 — 4 BIT REGISTER LATCH CIRCUIT DIAGRAM

BIT (1–4) ⇒ MSB OUTPUT FROM A/D CONVERTER
BIT (5–8) ⇒ LSB OUTPUT FROM A/D CONVERTER
Q(1–4) ⇒ LSB OUTPUT FROM REGISTER 1.
Q(5–8) ⇒ MSB OUTPUT FROM REGISTER 2.
V05 — ENABLES THE TWO REGISTERS.

(NAND GATE LATCH). This in turn prevents any further clock pulses being sent to the counter, and the state of the counter will be a digital work proportional to the analogue voltage.

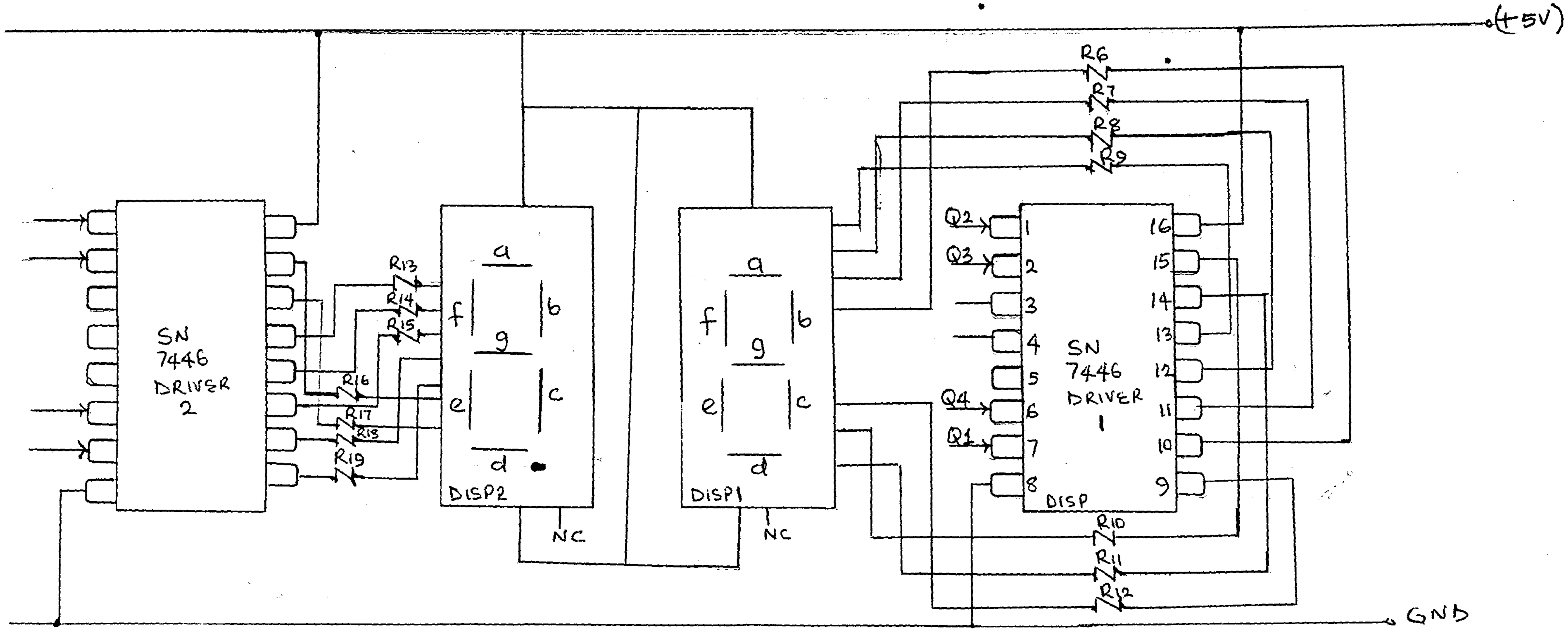
The 8-bit digital output comes out from the ZN425E pins 5-13, except pin 8 pins (5 - 7) and 9 is the LSB (lowest significant bit) while pins (10-13) is the MSB (most significant bit). The LSB is fed into input pins of the 4-bit bistable latch and also the MSB is fed into input pins of the second 4-bit bistable latch.

2.9. 4-BIT BISTABLE LATCH

These latches are ideally suited for use as temporary storage for binary information between processing units and input/output unit. Informations from the LSB and MSB get at the data inputs, pin (2, 3, 6 and 7) is then transferred to the outputs pins (16, 15, 10 and 9), when the enable (G) is HIGH, and the (Q) outputs will follow the data inputs as long as the enable remains HIGH. When the enable goes LOW, the information (that was present at the data inputs at the time the transition occured) is retained at the Q outputs until the enable is permitted to go HIGH. There are two of this 4-bit bistable latch used, one for the LSB and the other for MSB of the A/D converter. ZN425E. See figure 2.9

2.10. BCD-TO-SEVEN-SEGMENT DECODER DRIVER

The circuit configuration of this stage using 7446 ICs is as shown in figure 2.10. As shown in the figure, two



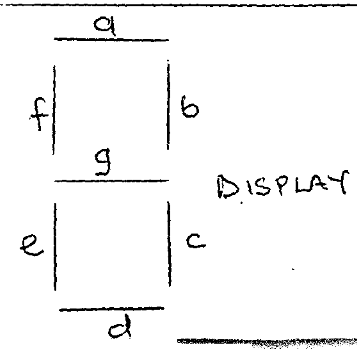


FIG. 2.10 — BCD-TO-SEVEN SEGMENT DECODER DRIVER WITH DISPLAY CIRCUIT.

R6 – R19 = 220Ω

* NC ⇒ NO CONNENTION.

sections are involved: LSB and MSB each one decoding the BCD numbers applied to the inputs pin (7, 2 and 6) labelled A,B,C and D.

The chip is a 16-pin IC with active LOW outputs that will drive LEDs (Seven segment display) through current-limiting resistors, to display the decimal numbers.

2.11. DESIGN CALCULATION FOR CURRENT LIMITER RESISTOR

The 7-segment LED display is rated to operated at 10mA and 2.7V for normal brightness. Thus the voltage drop across the series resistors. R is equal to different between Vcc = 5V and the segment voltage of 2.7V.

That is, Voltage across R, = 5 - 2.7 = 2.3V

Thus $R = \frac{2.3}{10mA} = 230$

A standard value of R = 220 was used.

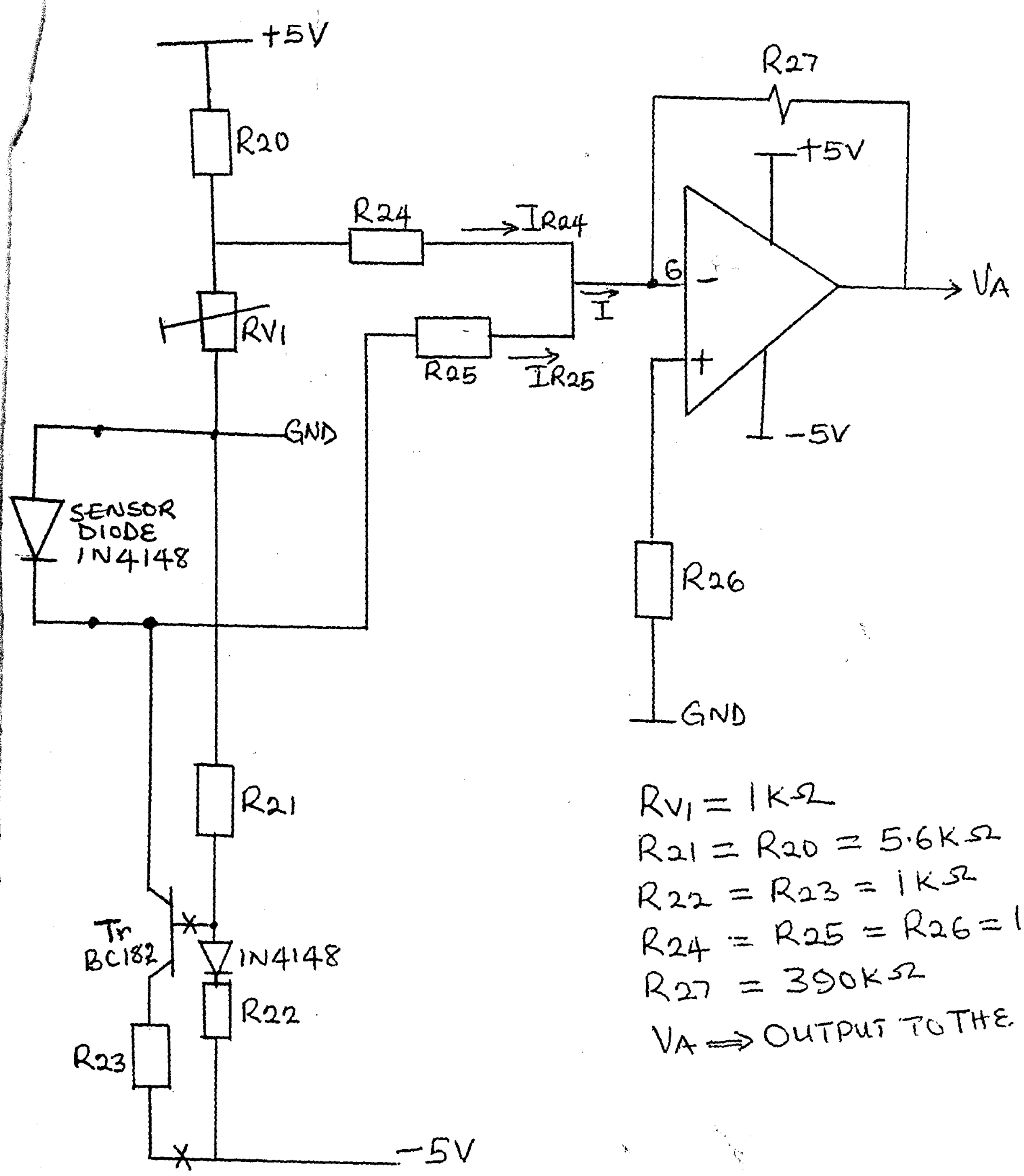
R = 220 (Desired value).

2.12. THE AIR TEMPERATURE SENSOR CIRCUIT

The circuit diagram is shown in figure 2.11. The air temperature sensor uses a forward biased silicon diode which is supplied with a constant current from Tr. The changes in temperature causes the voltage across the diode to drop by about 2mV/ c.

But the forward voltage drop of 500mV is eliminated by mixing the diode signal with a.d.c. level of opposite polarity from the junction of R4 and RV1 (the variable resistor).

The inventing op-amo circuit then tives an output



$R_{V1} = 1K\Omega$

$R_{21} = R_{20} = 5.6K\Omega$

$R_{22} = R_{23} = 1K\Omega$

$R_{24} = R_{25} = R_{26} = 10K\Omega$

$R_{27} = 390K\Omega$

$V_A \Rightarrow$ OUTPUT TO THE COMPARATO[R]

FIGURE 2·11 — AIR TEMPERATURE SENSING CIRCUIT.

signal of about 50mV/ c change.

2.13. DESIGN CALCULATION FOR THE AIR TEMPERATURE CIRCUIT

ANALYSIS OF THE TRANSISTOR BIASING

From fig. 11 R21 and R22 provides the effective voltage, V1, supply. Therefore using thevenin theorem to the circuit at points XX, we've

$$V1 = \frac{R22}{R22 + R21} \times 5V$$

$$= \frac{1}{5.6 + 1} \times 5V$$

$$= \frac{5}{6.6}$$

$$= 0.76V \text{ (base voltage)}$$

And for RB (base resistance), we've

$$RB = \frac{R22 \times R21}{R22 + R21}$$

$$= \frac{1 \times 5.6}{1 + 5.6}$$

$$= \frac{5.6}{6.6}$$

$$= 0.85K\Omega$$

Now, equating the voltage drops around the circuit.

$$V1 = IbRB + Vbe + Ie\ Re$$

but since $Ie \simeq Ic$

Then,

$$V1 - Vbe = IbRB + Ic\ Re \text{ and } Ib = \frac{Ic}{hfe}$$

$$V1 - Vbe = \frac{Ic\ RB}{hfe} + Ic\ Re$$

$$= Ic\left(\frac{RB}{hfe} + Re\right)$$

implies

$$I_c = \frac{V_1 - V_{be}}{\left[\frac{R_B}{h_{fe}} + R_e\right]}$$

but, Vbe for solicon is equal to 0.7V and hfe = 150

Now, inserting numerical values; we've

$$I_c = \frac{(0.76 - 0.7)V}{\left(\frac{0.85}{150} + 1\right) K\Omega}$$

$$I_c = \frac{0.06V}{1.005667\ K\Omega}$$

$$= 0.0597mA$$

$$= 0.06mA$$

Therefore

$$I_b = \frac{I_c}{h_{fe}}$$

$$= \frac{0.06}{150} mA$$

$$= 0.4\ \mu A.$$

ANALYSIS OF THE OP - AMP. BIASING.

for the maximum flowing through R24, we've

$\frac{RV1}{Rv1 + R20}$ x 5V (would be the maximum voltage across RV1)

$\frac{1}{5.6 + 1}$ x 5V = 0.76V

Therefore

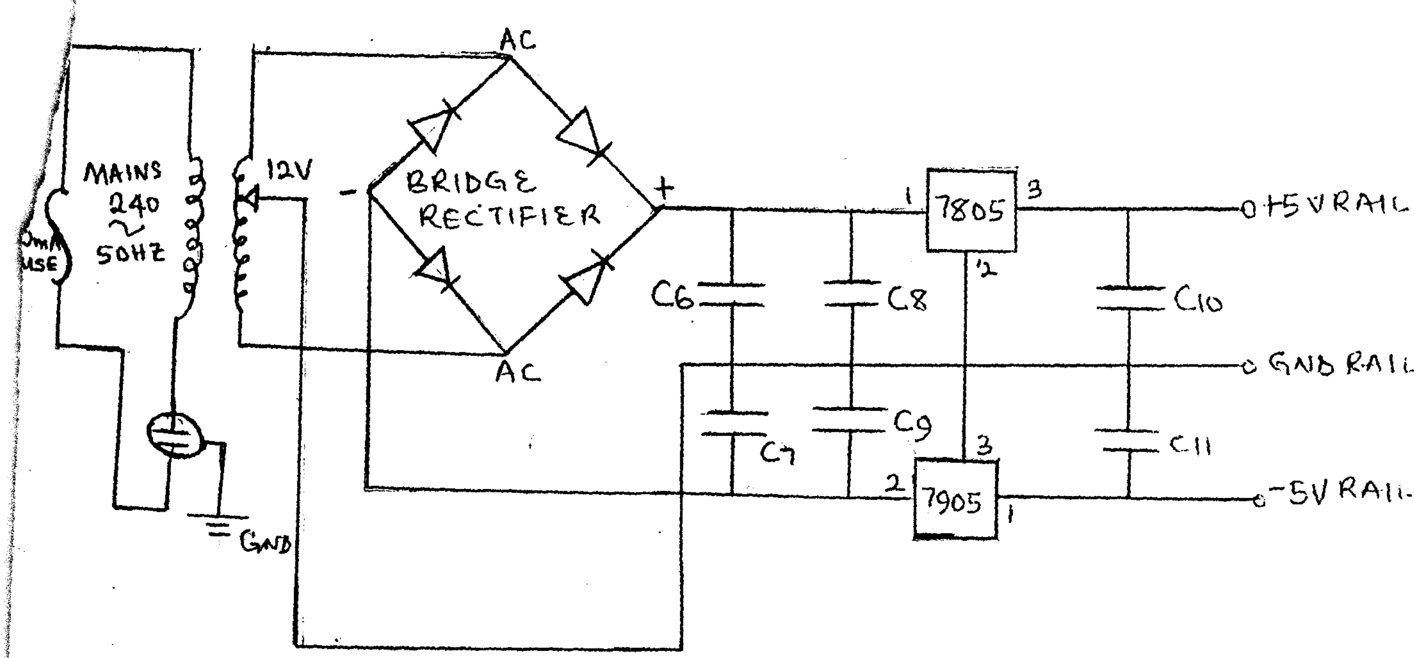
$$IR24 = \frac{0.76V}{10K\Omega}$$

$$= 0.076mA$$

$$= 0.08mA$$

Similarly, current flowing through R25 is

$$IR25 = I_c = 0.06mA.$$



C6 = C7 = 2200μF, 25V
C8 = C9 = C10 = C11 = 0.25M, 25V
BRIDGE RECTIFIER ⇒ DX, BB600
12V CENTER TAP TRANSFORMER.
7805 (+5V) VOLTAGE REGULATOR.
7905 (-5V) VOLTAGE REGULATOR.

FIGURE 2.12 - DUAL VOLTAGE ±5V POWER SUPPLY UNIT

Therefore

$$IR25 + IR24 = I$$

$$I = (0.08 + 0.06)mA$$

$$= 0.14mA.$$

The voltage output from this summing inverting amplifier, VA is

$$VA = \frac{R27}{R24} \times VR24 - \frac{R27}{R25} \times VR25$$

$$= \frac{390}{10} \times 0.76 - \frac{390}{10} \times 0.6$$

$$VA = (29.64 - 23.4)V.$$

$$= 6.24V.$$

2.14. POWER SUPPLY UNIT

The connection of the dual voltage ±5V power supply used in this project work is shown in figure 2.12. A 12V center tap transformer was used. The outputs from this transformer was fed into the bridge rectifier. As it has been shown in the figure, some capacitors were used for filtering to remove ripples. The 7805 was used as +5V voltage regulator and 7905 as -5V voltage regulator.

The bridge rectifier used is DX, DB 600. Also the capacitors used are

C6 = C7 = 2200µF, 25V

C8 = C9 = C10 = C11 = 0.25m, 25V.

CHAPTER THREE

THE CONSTRUCTION AND TESTING

The circuit was constructed by soldering the various components on the Vero board (strip board) using the circuit diagram of figure 3.0. The soldering of the components were done stage by stage (that is in modules), testing before proceeding to the next, was carried out at each stages. Except for the analogue to digital converter IC chip, all other IC chips were not incorporated using IC sockets already soldered on the board.

All components used was powered using the ±5V rail of the power supply unit with the exception of the air temperature sensing circuit which was operated using the +5V rail of the power supply unit. The +5V dual voltage supply was obtained by soldering +5V voltage regulator IC (7805) and -5V voltage regulator IC (7905) on the board with +12V center tap, applied to its inputs pins and the output pins were connected to the +5V and -5V rail respectively.

The air temperature sensing circuit was soldered as patterned in the figure 3.0. The operational amplifier used in the sensing circuit is acting as summing inverting amplifier. The output at this stage comes out from pin 7 of the op-amp, VA. The comparator circuit was then soldered. At the end of the soldering, the output from the sensing circuit, VA and output from pin 14 of the analogue to digital converter, VA1 were soldered to the non-inverting, pin 7 and to the inverting, pin 6 of the comparator.

The next stage was the soldering of the two astable multivibrator, and a multimeter was used to test the continuity and discontinuity of certain points on the board. The circuit was tested with pin 8 and pin 4 of the 555 Timer to the +5V rail and the resulting generated pulses were displayed on the oscilloscope, and the amplitude and frequency of the pulse were observed through the scope. The two astable multivibrator were biased differently at different frequency.

The NAND GATES circuit was soldered next, and the outputs of the two astable multivibrator and comparator were applied to pins 5, 10 and 1 of the NAND GATES (CE 74S00N). This circuit has its putput from pin 8, V02.

The analogue to digital converter circuit was the next stage that was soldered. The output from the astable multivibrator 1, V03, was applied to the reset input of this circuit. Similarly to the cout input of this circuit, the output from the Nand gate circut, pin 8 was applied. This circuit has its output as digital from pin 5 - 13 except pin 8.

The 4 bit bistable latch circuit was soldered next. There are two of it. One is for Lower Significant bit and the other is for High significant next. Pin 4 and pin 13 of each circuit were soldered in cascading and the output from pin 8 of the nand gate circuit was fed into it, to enable the circuits. The digital output from the analogue to digital converter was applied to the inputs of these circuits accordingly. These circuits also have their own putputs that was applied to the next stage.

The decoder driver circuits was soldered next. The outputs of the last stage was applied into the inputs of this circuits. There are seven outputs from each circuit.

Succeeded the last stage is the soldering of the 7-segments displays. Each seven outputs from each circuit of the last stage were applied to (a - g) inputs of each display.

Testing in this project was carried out effectively and in the cause of this process some IC chips got burnt and were replaced.

CHAPTER FOUR

CONCLUSION

The design and construction of a simple digital air temperature reading device has been presented in this project. It has the ability to sense the air temperature, which is in an analogue form then it is converted into digital bits for easy display on the seven segment display. The result got is easily readable unlike using clinical and mercury home thermometers which required more time before one could get the acceptable result of the surrounding.

This project is quite important, for it could be used in weather forecasting, in laboratories just to mention but few.

TABLE I: COMPONENT USED

RESISTORS	CAPACITORS	INTEGRATED CIRCUITS (IC)
R1 = 2.2MΩ	C1 = 10 UF	555 TIMER
R2 = R5=R22=R23=1KΩ	C2 = 470nF	LM339N
R3 = 2.2KΩ	C3 = C4 = 10nF	CE 74500N
R4 = 22KΩ	C5 = 0.22µF	ZN 425 E
R6 - R19 =220Ω	C6 = C7= 2200µF,25V	BC 182
R20 = R21 = 5.6KΩ	C8=C9=C10=C11=0.25M 25V.	LF 353N
R24 = R25 = 10KΩ		IN 4148
R27 = 390KΩ		SN 7446 AN
		COMMON-ANODE LED DISPLAY
		SN 74 LS 75 N.
		DR1 DB600 (BRIDGE RECTIFIED)
		(7805)+5V regulator
		(7905)-5V regulator
		POTENTIOMETER
		RV1 = 1k.

TABLE II: COST ANALYSIS

NO.	DESCRIPTION OF COMPONENTS	QTY	UNIT PRICE N	TOTAL COST N
1.	RESISTOR	27	3.00	81.00
2.	CAPACITORS (LARGE)	2	25.00	50.00
3.	353 op. amp	1	25.00	25.00
4.	ZN425E	1	200.00	200.00
5.	555 TIMER	2	35.00	70.00
6.	7475 LATCH	2	30.00	60.00
7.	7446 DRIVER	2	30.00	60.00
8.	7-SEGMENT DISPLAY	1	35.00	70.00
9.	339 COMPARATOR	1	35.00	35.00
10.	7400 NAND GATES	1	30.00	30.00
11.	BC 182 TRANSISTOR	1	25.00	25.00
12.	IN4148 DIODE	2	10.00	20.00
13.	7805 (+5V) REGULATOR	1	25.00	25.00
14.	7905 (-5V) REGULATOR	1	25.00	25.00
15.	VERO BOARD	1	100.00	100.00
16.	LED	1	2.00	2.00
17.	CAPACITOR (SMALL)	9	4.00	36.00
18.	12V CENTER TAP TRANSFORMER	1	60.00	60.00
19.	13A FUSE PLUG	1	15.00	15.00
20.	POTENTIOMETER (1K)	1	6.00	6.00
21.	BRIDGE RECTIFIER	1	15.00	15.00
			TOTAL =	₦1,010.00

APPENDIX I

ANALYSIS OF OPERATION OF THE 555 TIMER AS AN ASTABLE MULTIVIBRATOR

The internal configuration of the 555 timer is as shown in figure A.

The external circuits consists of dc voltage supply, Vcc, resistor RA and RB and capacitor C. The basis of the circuit is a flip-flop with sets and resets inputs controlled by comparators. The two comparators sense the voltage present on the capacitor C. The two comparators use as reference voltage respectively one-third and two-third of the power supply voltage, Vcc. Initially the capacitor charges through RA and RB until it reaches Vmax = 2/3 Vcc. At this point comparator A sets the flip-flop, which in turn causes the transistor (T) to saturate. The capacitor then starts discharging through RB and T until it reaches Vmin = 1/3 Vcc at which point it triggers comparator B, resetting the flip flop and complete a cycle. The capacitor begins to re-charge and the process repeats itself infinition with the capacitor oscillating between 1/3 Vcc and 2/3 Vcc.

DERIVATION OF FREQUENCY OF OSCILLATION AND DUTY CYCLE

As shown in the sketch given in figure A, the output is HIGH as the capacitor changes through RA and RB initial voltage of 1/3 Vcc to 2/3 Vcc.

assume,

t1 = time the output is HIGH

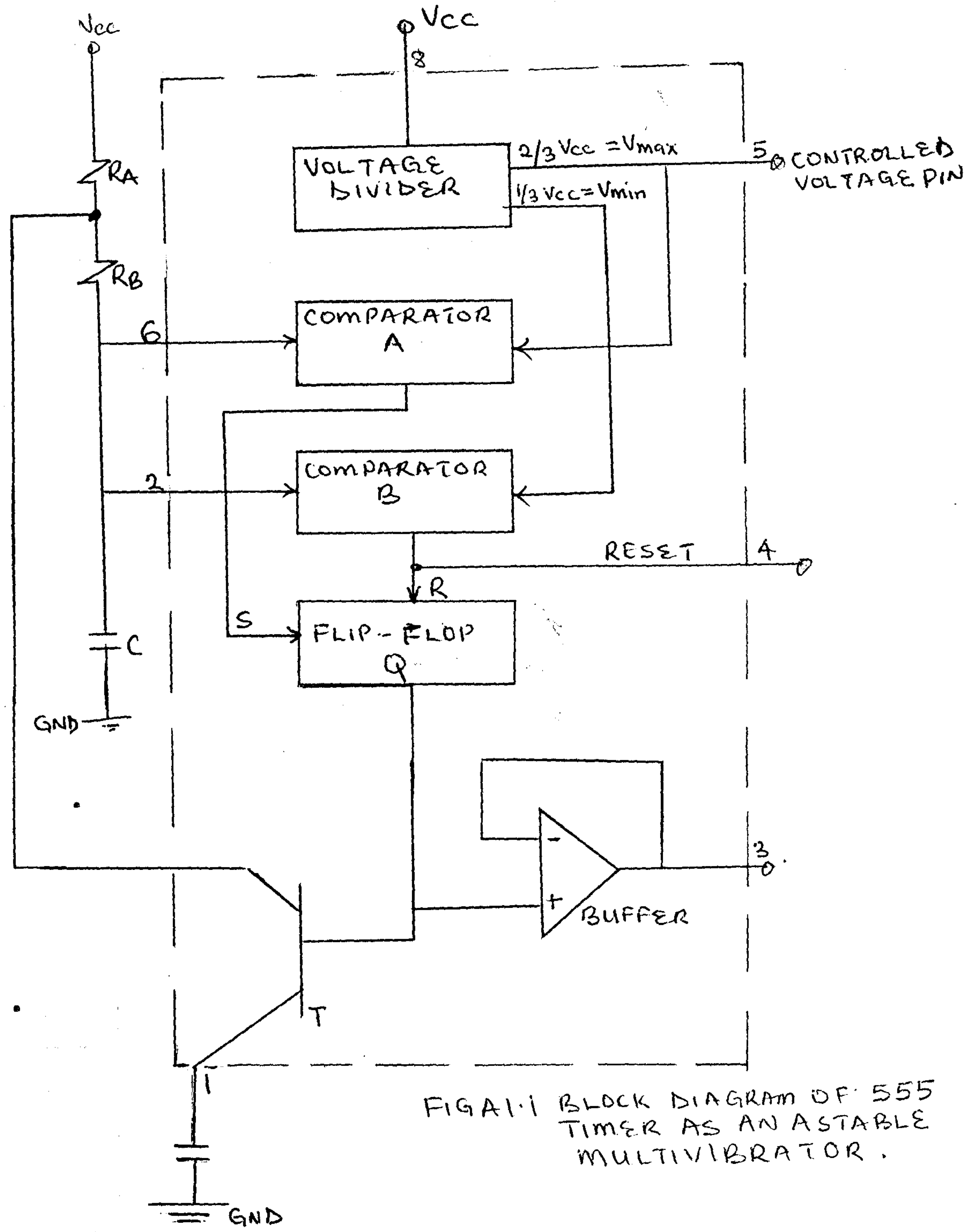


FIG A1.1 BLOCK DIAGRAM OF 555 TIMER AS AN ASTABLE MULTIVIBRATOR.

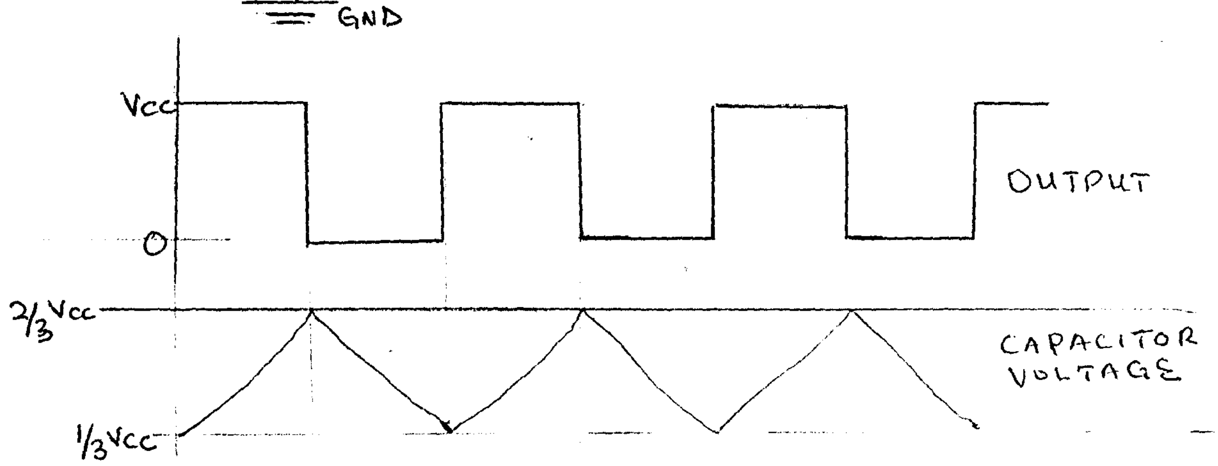


FIG A1.2: OUTPUT AND CAPACITOR VOLTAGE WAVE FORMS

V = voltage across the capacitor

$$V = Vcc - (Vcc - 1/3\ Vcc)^{\_t/RC}$$

Rt = RA + RB

As t = t1 V = 2/3 Vcc

$$2/3\ Vcc = Vcc - (Vcc - 1/3\ Vcc)^{\_t1/RC}$$

$$(Vcc - 1/3\ Vcc)\ e^{\_t1/RC} = Vcc - 2/3\ Vcc.$$

$$2/3\ Vcc\ e^{-t1/RC} = 1/3\ Vcc$$

$$2e^{-t1/Rc} = 1$$

t1 = CR1n2 ; R = (RA + RB)

Also assume,

t2 = time the output is LOW

$$V = 0 - (0 - 2/3\ Vcc)e^{-t/RC}$$

At t = t2, V = 1/3 Vcc

$$1/3\ Vcc = 2/3\ Vcc\ e^{-t2/RC}$$

$$1 = 2e^{-t2/RC} \quad ; \quad R = RB$$

t 2 = CR In2 ; R = RB

Total time T = T1 + t2 = period.

t1 = C(RA + RB)In2

t2 = C (RB) In2

T = C In2 (RA + RB + RB)

T = C(RA + 2RB) 1n2

= 0.0693 C(RA + 2RB)

f = frequency of Oscillation.

$$= \frac{1}{period}$$

$$\text{that is } f = \frac{1}{T}$$

$$\text{Thus } f = \frac{1}{0.693\,(RA + 2RB)C}$$

$$= \frac{1.44}{(RA + 2RB)C}$$

$$\text{Duty cycle} = \frac{t1}{T}$$

$$= \frac{C(RA + RB)\ln 2}{C(RA + 2RB)\ln 2}$$

$$= \frac{RA + RB}{RA + 2RB}.$$

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