DESIGN AND CONSTRUCTION OF A MICROCONTROLLER BASED TEMPERATURE CONTROLLED FAN SPEED REGULATOR WITH A DIGITAL DISPLAY

DUNMOYE, FEYISAYO ABIBAT

2003/15351EE

A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE, NIGERIA.

NOVEMBER 2008

DEDICATION

This work is dedicated to almighty ALLAH for sparing my life till this moment and also for making it possible for me to always glorify Him.

DECLARATION

I Dunmoye Feyisayo Abibat declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copy right to the Federal University of Technology Minna.

DUNMOYE.F.ABIBAT
Student

14/11/08
....
Signature and date

ENGR J.G. KOLO
supervisor

....
Signature and date

ENGR. DR. Y.A. ADEDIRAN
H.O.D

....
Signature and date

....
External Examiner

....
Signature and date

AKNOWLEGDEMENT

Praises and adorations be to the sovereign of heaven and the earth for coordinating our affairs, I thank Him for giving me the ability to overcome the ups and downs of running a successful degree program, pray that He crown all my efforts with success in this world and hereafter.

I would like to appreciate the invaluable contribution of my honorable supervisor Engr.J.G. Kolo for his captivating supervision. I shall also remain grateful to the Head of Department, DR.Y.A.Adediran.

My sincere gratitude goes to my lovely parent Mr. and Mrs. R.A Oladunmoye for their spiritual, financial and moral supports, may the almighty make me a good child for them in both worlds. My lovely siblings, Dunmoye.O.Akeem, Ismail, Ramat, Ganiyat, I acknowledged your effort on me, may ALLAH reward you in abundance.

A well deserving appreciation goes to Engr Chris Olumide for his technical advice and support during this project, may ALLAH spare us for each other and make our relationship an eternal one AMEEN. I also acknowledge all my most esteemed friends and colleagues; Isangedige Emmanuel, Ayanda.F.K, Orugun Kunle, Awobade Ayodele, Jimoh Teslim, Sister Fatimah, Babatunde Fumbi and Adekanye Abimbola you are all appreciated, infact, I give thanks to Allah for our lives may He continue to strengthen our bond.

ABSTRACT

This project is the design and construction of a microcontroller based temperature controlled fan speed regulator with a digital display, which enables user to control the speed of fan automatically with ambient temperature of the room. The device contains a temperature sensor (LM35) whose output voltage is a direct function of the ambient temperature of its immediate environment, an analogue to digital converter and an 89S51 microcontroller which commands the control unit via a power triac (BT139). The corresponding speed was displayed on a seven segment display (a speed of 0 to 9 was controlled).The system was broken down into units for simplicity. The work yielded the desired results.

TABLE OF CONTENTS

Chapter Three: Design and Implementation

Chapter four: construction, Test, Result and discussion

Chapter five: Conclusion and recommendation

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

This project is another step in the quest for the improvement of man's living conditions. The introduction of the electric fan has brought much comfort and luxury to mankind, due to its economic value and its easy maintenance.

The electrical energy supply to the motor rotates the rotor at a speed that is proportional to the input voltage The rotor rotates the fan blade with a force that is proportional to the blade's speed.

Since users have different desire at which the fan should rotate, depending on the temperature rise, the fan regulator is there to give desired speed of the fan blade by regulating the input voltage, which is proportional to the speed of the blade rotation

To increase its comfortability, a temperature-sensing fan regulator is introduced. It automatically switches on an electric fan as the ambient temperature exceeds any limits you select and then go off as the temperature falls below this limit In other words, the circuit monitors the ambient temperature of the room and control the speed of the room fan in accordance with the room temperature. The reference speed of the fan in relation to the ambient temperature can easily be set by the user.

1.1 AIMS AND OBJECTIVES

The aim of this project work is to design and construct a microcontroller based temperature controlled fan-speed regulator with a digital display (which displays the corresponding speed of the fan in accordance to the room temperatures) and a manual setting.

The objective of the project is as follows:

- To design a simple cost effective device.
- To create awareness and also make fellow students appreciate the versatility of electrical and computer engineering in relation to other fields of engineering and sciences.
- To demonstrate how DC power can be used to control AC power
- To demonstrate how a temperature sensor can be used to control the action of temperature appliances
- To construct automatic regulation system that can efficiently regulates the speed of the fan.
- To provide an alternative to the manual fan speed control

1.2 METHODOLOGY

This project work was carried out in units for ease of design and construction Each of which was carefully designed and constructed in a sequential order. The assembly of all the units forms the complete work.

The major units of this project are briefly stated as follows:

- The power supply employs a 12V 0.5A which was connected to a bridge rectifier to provide a DC output.
- The zero crossing detector reshapes the equivalent voltage into a rectangular (pulse) signals.
- The transducer coverts temperature to its proportional voltage
- The analogue to digital converter converts it analogue input to its corresponding digital output.
- The Control Unit derives the necessary information needed to set the fan speed from the converted temperature value using a (8951 micro-controller)
- The display unit provides a feedback for the user

The block diagram of the design is as shown in fig1.0.

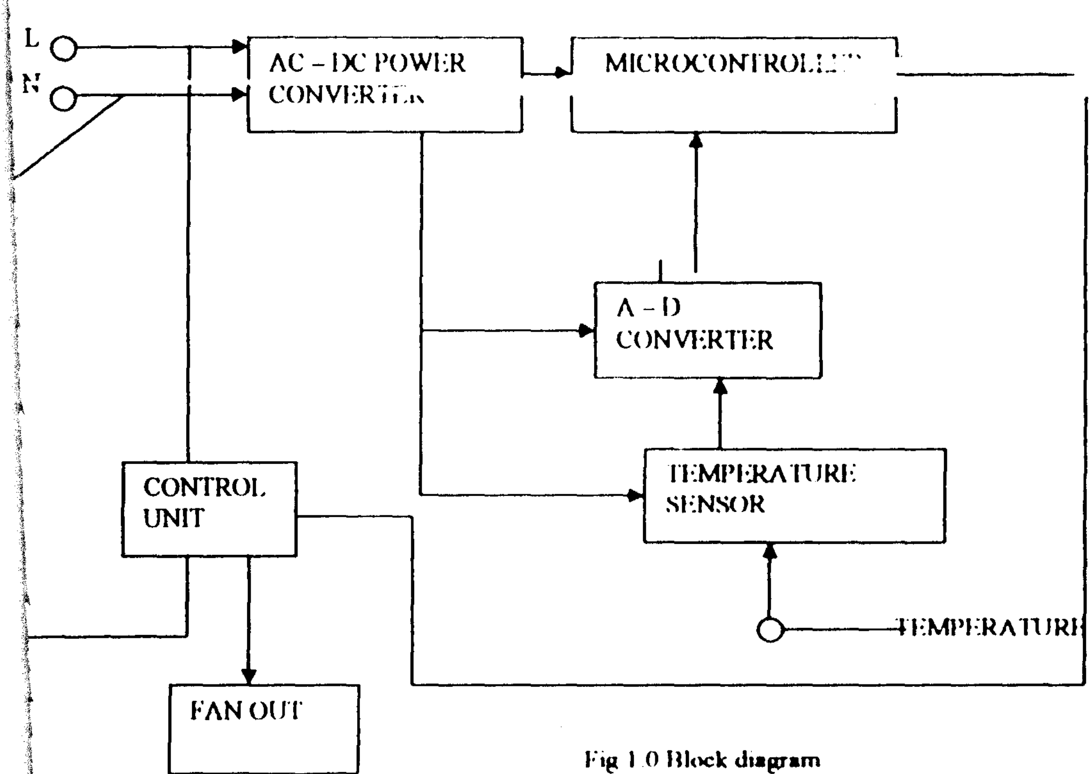

Fig 1.0 Block diagram

1.3 SCOPE OF THE WORK

The temperature controlled fan speed regulator makes use of a temperature Sensor (LM35) whose output voltage is directly proportional to its Celsius temperature.

A preset value of temperature is programmed with the aid of an 8951 microcontroller.

Basically, it operates in the following manner; a sensor detects the ambient temperature of the room at a point in time. The temperature is read and converted to digital quantities, manipulated by the control unit via the microcontroller. If the temperature value falls below the programmed value, the fan remains in OFF state, otherwise, it remains in ON state which switches the triac and rotates the fan. Therefore the speed of the fan depends on the temperature level of the room

CHAPTER TWO

LITERATURE REVIEW/THEORETICAL BACKGROUND

2.1 BRIEF HISTORY OF FAN

The earliest known fans are called screen fans' or fixed "leaf fans". These were manipulated by hand to cool the body, to produce breeze, and to ward off insects. Such early fan usually took the form of palm leaves. Some of the earliest known fans have come from Egyptian tombs. Fan history stretches back thousands of years, which have dual function that is, a useful ornament and a status symbol. In their development, fans are made of varieties of materials, some of them are quite decorative while others are art works for attraction. [1]

In the ancient America and South American cultures used bird feathers in their fans. Among the Aztec fans were used to depict merchants in illustrations of trades. In Rome, gilded and painted wooden fans were used. In China screen fan were used throughout society. [1]

It was known that around the middle 1700s inventors started designing mechanical fans, while in 19^{th} century in the west, European fashion caused fan decoration and size to vary.

The first recorded mechanical fan was the Tunkah fan used in the Middle East in the 1500s. [1] Nikola Tesla made the birth of electrical fan. Dr Schuyler Jkaats Wheeler developed the two bladed desk fans. [1]

In the 1950s fan were manufactured in colours that were bright and eye catching.

Recently, domestic fans are of two main types, namely; the ceiling and standing table fan. As technology advances, different types of regulators emerged as we shall see below.

2.2 TYPES OF FAN SPEED CONTROL

Controlling the speed of the fan can be as simple as regulating the input voltage of the fan to using more complicated digital microprocessor inputs. These methods are further addressed below.

2.2.1 VOLTAGE REGULATION

This option is designed for applications where the input power may fluctuate at different voltage levels. It is accomplished by using a voltage regulator and changing the adjust leg with a zener-diode. [2]

2.2.2 PROGRAMMABLE

Programmable fan allows you to control the speed of the fan to optimize cooling performance. This option can be by pulse width modulation or vary the voltage, otherwise vary the resistance. [2]

For pulse-width modulation (PWM), the pulse signal should be applied to the program lead (yellow wire) and referenced to the return load. In PWM, by means by applying voltage ON and OFF, the amplitude should be equal to the nominal voltage of the fan at a constant frequency. Duty-cycle adjustments are made to control the speed of the fan.

Varying the resistance or voltage is accomplished in the same way as pulse-width modulation PWM, the difference is that Voltage/Resistance is varied linearly instead of varying the duty cycle. [2]

2.2.3 THERMAL SPEED CONTROL

The concept of thermal speed control does not need any external input. It uses a thermistor to monitor the temperature and regulate the speed accordingly. The thermistor's metal properties allow it to change its resistance at different temperature, thus, creating a variable voltage divider circuit at the adjust leg of the voltage regulator. The fan will automatically adjust its speed to optimize the air flow to the surrounding temperature. [2]

2.2.4 EXTERNAL CONTROLLERS

This may include using multiple temperature sensor, different set speeds per fan or other combinations. For cases where complicated mapping functions are needed, the only choice is to use a microcontroller which we are going to implement in this project work.

2.2.5 LINEAR REGULATION

Linear regulation adjusts the voltage across the fan by using a linear regulator. [2] The linear regulation option is designed for application where the input power may fluctuate at different voltages across the fan levels. The linear speed regulators work by controlling the voltage across the fan. It is done by dissipating power in the form of heat in the pass element. [2]

2.2.6 AC REGULATION

The concept of AC regulation is based on the operation of an Auto-transformer. The speed of a fan is directly proportional to the increase in power dissipated into the system. The power dissipated in the coil is in response to the exponential increase in the number of coils and thickness of the wire.

Number of coil determines the voltage while wire thickness determines current flowing through the coil

Thus the change (increase) in the number of coils increases the speed of the fan at different voltage level

2.3 REASON FOR FAN SPEED CONTROL

Below are some the reasons and benefits of fans speed control

2.3.1 REDUCE POWER CONSUMPTION

Controlling fan speed ensures that fan speed is reduced when less cooling is required which eradicates power wastage. When the fan speed is reduced, the power consumption is also less. This results in power saving. [3]

2.3.2 REDUCE AUDIBLE NOISE

Fan running at full speed causes turbulent air flow which is the most dominant sources of fan noise. Employing fan speed control eliminates the operation at full speed when not required .|Hence noise is minimized. [4]

2.3.3 INCREASED LIFE SPAN

Reducing fan speed when necessary also decreases the wear on the fan. Fan wear is a rough function of the absolute number of revolutions of the fan. When the wear of the fan is reduced, its life span is thus increased with a greater meantime between failures (MTBF) because fans are mechanical they tend to be one of the common failures on a system. [2] .

2.4 BRIEF HISTORY OF TEMPERATURE

Temperature is defined as the measure of average translational kinetic Energy associated with the disordered microscopic motion of atoms and molecules. It determines ones sensation of warmth or coldness felt from contact with it. [5]

Temperature is the most measured parameters. Fire is hot and snow is cold, greater knowledge was gained as men attempted to work with materials through the bronze and iron ages. [5]

A temperature regulator is a device for detecting and controlling the temperature of a system or place within a particular specific range. [6] The temperature regulator reads temperature in Celsius. The Celsius scale used to be called the centigrade scale.

The absolute temperature or Kelvin scale was proposed by Sir William Thomson, Baron Kelvin of large and Lord Kelvin of Scotland, in the year 1848. This scale had its zero degrees as being the theoretical lowest temperature possible (i.e. where molecular motion ceases). This value turned out to be -273.16 degree Celsius. The degree Kelvin is the current standard unit of temperature. [6]

The early thermometers were non-electric in nature because they used thermal expansion of matter i.e. solids and liquids. [7] They had the disadvantage of possessing a limited temperature range and were also subject to reading error. [8] In the "Design and Construction of a Temperature Induced Automatic Room Fan Regulator" by Adeyi Bashir, the author employed a thermistor (Thermal Resistors) as his temperature sensor and his recommendation proposed the use of Integrated Circuit Sensors for better linearity and accuracy. [9]

Thereafter, in "The Design and construction of a Temperature Sensing Fan Regulator with speed Setting Remote Control". By Kasai, A. E.; the author made use of an LM339 quad Comparator Circuit, which will compare the voltage input I.e. The first input varies with temperature change and the other is fixed, based on the setting made. [10] His recommendation also employs the use of Integrated Circuit Sensor and the circuit size of the project.

This project work has made advancement to these earlier works by putting the added feature of a temperature sensor (LM35) because it can measure temperature more accurately than using thermistor, it's sensor circuitry is sealed and not subject to oxidation and can generate a higher output voltage than thermocouple and may not require that the output voltage be amplified. Also a micro controller that allows the output signal to be displayed on the seven segment display unit (LED)

2.5 THEORETICAL BACKGROUND

The microcontroller based temperature controlled fan speed regulator with digital display can be broken down into units namely; power supply unit, control unit, system controller, Analogue to digital converter, temperature sensing unit and display unit (seven-segment).

2.5.1 POWER SUPPLY

The power supply circuit is obtained from a 220V50Hz mains input by means of a 20:1 step down transformer to regulate a 5V DC supply derived from a 12V0.5A AC50Hz. The 12VAC input is rectified by a bridge rectifier, then, there's a zero crossing detector device which helps reshape into a pulse wave and then smothered by a 25V2200μF and 16V2200μF, regulated by a 7805 regulator to produce a ripple – free 5V DC output.

2.5.2 CONTROL UNIT

The control unit is associated with the device that switches the fan. In this project, we shall incorporate BT139 power triac to serve as a switch. It is a 5-layer bi-directional device which can be triggered into conduction by both positive and negative voltage at its anode and with both positive and negative triggering at its gate. It behaves like two SCR (silicon controlled rectifier) connected in parallel, upside down with respect to each other [11]

The BT139 power triac is powered on by a MOC3023 opto-triac which receives command from the 89S51 microcontroller.

2.5.3 SYSTEM CONTROLLER

The microcontroller comprises of central processing unit (CPU), instruction fetch and decoder, arithmetic logic unit, registers, all embedded into a single chip. The central processing unit (CPU) bundle with supporting components such as memory and I/O peripherals and this gives rise to microcomputers. Integrating all the elements of microcomputers onto a single chip is called microcontroller.

The AT89S51 shall be used. This is a low-power; high performance CMOS - 8 bit micro computer with 4 Kbytes of flash programmable and Erasable read only memory (PEROM). The device is manufactured by Atmel's high density non volatile memory technology and is compatible with the industry standard. MCS-51TM instruction set. [12] The on-clip flash allows the programmed memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit central processing unit (CPU) with flash on a monolithic clip. The 89S51 is a powerful microcomputer which provides a high-flexible and Cost-effective solution to many embedded control. [12]

The 89S51 provides the following standard features: 4kbytes of flash, 128bytes of RAM, 32 I/O lines, three 16-bit timers, five vector two-level interrupt architecture, a full duplex serial port on-clip oscillator, and circuitry. Also, it is designed with static logic for operation down to zero frequency and supports two software selectable power saving mode. The idle mode stops the CPU while allowing the RAM, timer, serial port, and Interrupt system to continue functioning. The power down mode saves the RAM contents but freezes the oscillator, disabling all other clip function until the next hardware reset. [12]

2.5.4 ANALOGUE-TO-DIGITAL CONVERTER

The analog-to-digital converter (ADC) is an electronics circuit that converts an input analogue voltage to a digital number. [13] It converts continuous signals to discrete. All ADC's suffer from non-linearity error caused by their physical imperfection, causing their output to deviate from a linear function. The ADC used in this project work is the ADC 0804, which employs successive approximation as its conversion method. [14] It is used due to its availability and relative cheapness.

2.5.5 TEMERATURE SENSING UNIT

A temperature sensor/transducer is a device that senses temperature variation in an environment to give useful electrical signal. [15] Their properties changes with change in temperature. Various temperature sensors which are in use include: thermocouple, resistance temperature detector (RTD), thermistors and sensor Integrated circuits.

A Thermocouple consists of two different conductors couples together at their ends. As it senses temperature the thermoelectric voltage developed between the two junctions is proportional to the temperature, the device is used to measure the temperature of the other junction. It is also used to convert a radiant energy to fixed energy. A thermistor is a device whose resistance value changes with its temperature. [16] It offers greater accuracy and stability than thermocouples, [17] but its non-uniform resistance temperature characteristics can be disadvantageous in some application where it is required to obtain a more linear variation. [7]

The integrated circuit temperature sensor (LM35) is a precision semi-conductor giving an output of 10mV per degree centigrade. Unlike devices with outputs proportional to the absolute temperature (in degree Kelvin), there is no large offset voltage which in most application will have to be removed. It does not require any external calibration.

2.5.6 THE DISPLAY UNIT

The electronic display units are concerned with the visual presentation of small numeric and alpha numeric output information. [18] In this project, the display unit consists of seven-segment display chips connected to the micro controller.

A seven-segment display is an assembly of light emitting diodes (LED). The LED is an electro luminescent system that emits light when a voltage is impressed on it. [18] Other electro luminescent are the liquid crystal display (LCD) and the light emitting film (LEF). Each light emitting diode of the seven-segment display is powered individually and connected via a resistor. [15] The LED chips are connected in the common anode mode.

CHAPTER THREE

DESIGN AND IMPLMENTATION

The microcontroller based temperature controlled fan speed regulator with digital display was designed around;

1. Power Supply unit
2. An 8 – bit analogue – to – Digital Converter
3. A LM35DZ temperature – to – Voltage Converter (Sensor)
4. An 8 – bit Microcontroller (System Controller)
5. AC high power switch

3.1 POWER SUPPLY UNIT

The system supply was derived from a 12V, 0.5A step down transformer, a full wave bridge rectifier and a 7805 (5V regulator). The schematic is as shown in fig 3.0.

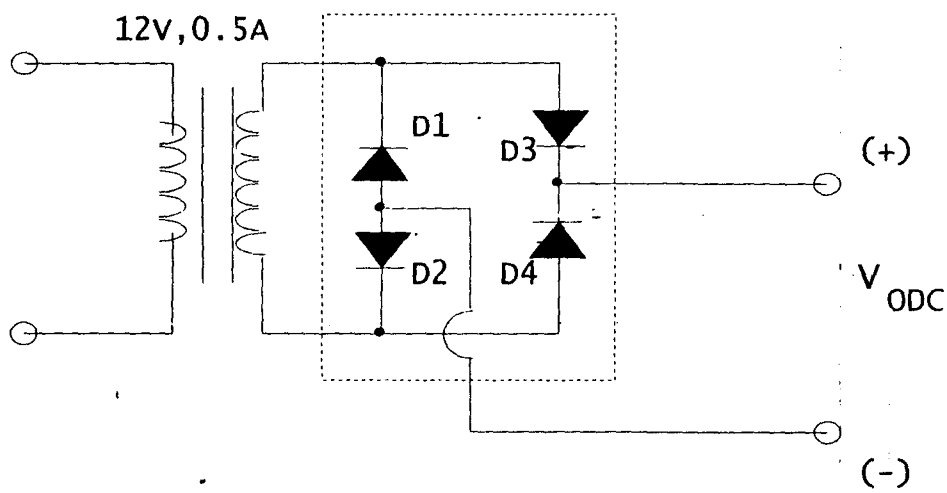

Fig. 3.0: Rectified power Supply

A transformer current of O.5A was chosen based on the maximum current consumed by the system.

- ADC 0804:- 2.5mA
- 7 Segment LED :- 70mA (10mA per segment)
- MOC 3023 Opto- triac :- 30mA
- 89S51 Microcontroller :- 10mA

The system Current Consumption was low enough for an O.5A transformer current to suffice. The 12VAC Voltage was converted to a 15.5V peak DC voltage by a full wave bridge rectifier.

$$V_{DC\,(peak)} = (Vrms\sqrt{2}) - 1.4$$

$$VC_{DC(Peak)} = (12\sqrt{2}) - 1.4$$

$$\approxeq 15.5V$$

This value of DC voltage was produced by reshapening into a pulse wave form with the aid of a two-stage transistors zero crossing detector before smoothening. The zero crossing detector was effected as shown below:

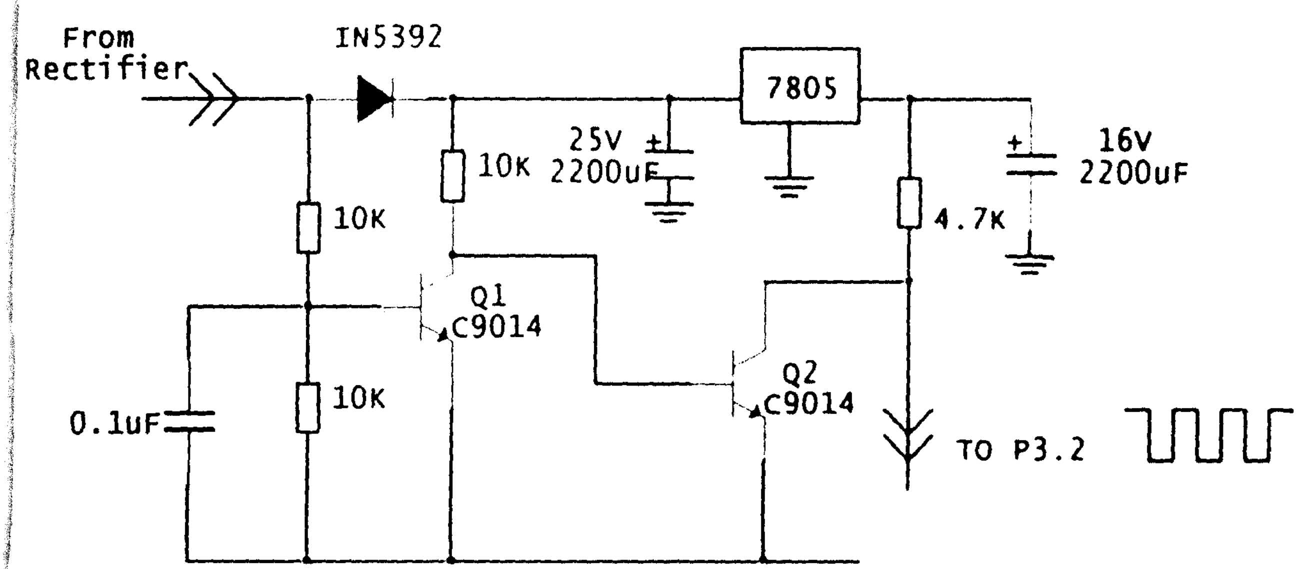

Fig 3.1: Zero Crossing Detector and Smoothening Circuit

Smoothening of the DC Voltage was done by a 2200μf capacitance of value deduced from;

$$Q = CV = IT.$$

Where

C = minimum value of smoothening capacitance

V = maximum allowable AC ripple superimposed on the DC Voltage

I = Maximum load Current

T = period of the rectified pulsating DC Voltage

But

$$T = \frac{1}{f} \text{ for half wave rectifier}$$

$$T = \frac{1}{2f} \text{ for full ware rectifier}$$

$$C = \frac{IT}{V}; = \frac{112.5mA \; x \; \frac{1}{2 \; x \; 50}}{\Delta V}$$

ΔV is the maximum AC ripple voltage. ΔV is obtained from the 7805's specification that an input – output differential of 2.5V minimum must exist to maintain regulation.

Therefore, for a 5 – Volt output, Vin (minimum) will be

$$5 + 2.5 = 7.5 \text{ Volts}$$

On a 15.5V pk – pk (peak to peak) input, the minimum input voltage to the regulator is 15.5 – 7.5 = 8V

Therefore, ΔV was fixed at 8V; So that

$$C = \frac{0.1125A \times 0.01}{8V} \quad 140\mu F$$

The above value of C is the minimum needed for effective regulation at an input AC Voltage of 240V. To maintain operation down to lower voltages, C has to increase. A value of 2200µf capacitance was chosen.

3.1.1 ZERO CROSSING DETECTOR

To obtain the control signals required for modulating the AC power fed to the load, a burst – fire (PWM) modulation of the 240V 50Hz AC power was implemented. Burst-fire Control involves passing or blocking of integral numbers of AC cycles from/to a load as shown below.

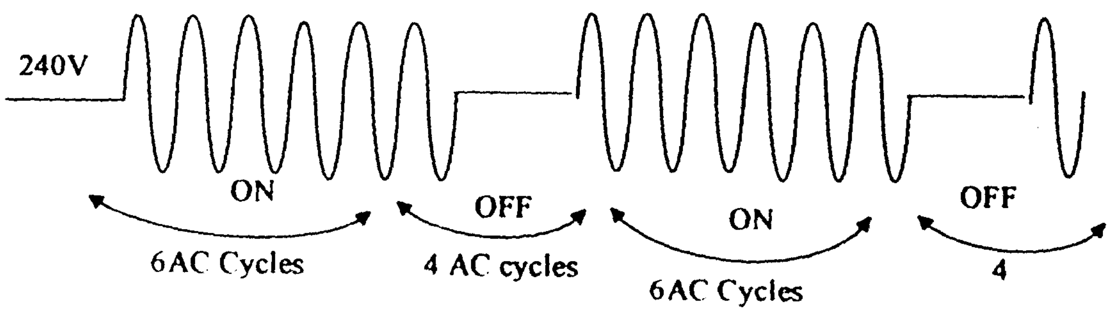

Fig 3.2 Illustration of burst-fire control

Fig 3.2 shows a power delivery of 60% into an AC powered load.

Ten AC cycles are controlled. The figure also shows 6 AC cycles passed into the load and 4AC cycles blocked. The average voltage across the load is thus

$$\frac{6}{10}(240V) = 144V$$

Assuming the power developed in the load at 240V AC input is Pwatts, the power developed in the load at 114V AC input is P_2: Therefore,

$$P = \frac{V^2}{R_L} \qquad \text{where } R_L = \text{Load Resistance}$$

$$V = \text{Voltage}$$

$$P_1 = \frac{240^2}{R_L}, \qquad P_2 = \frac{144^2}{R_L}$$

Since R_L remains constant,

P x V^2

$$P_1 = K240^2$$

$$P_2 = K144^2$$

$$\frac{P_1}{P_2} = \frac{144^2}{240^2}; \qquad P_2 = 0.6P_1$$

Thus in the example diagram above, the power developed is 60% when 6 AC cycles are passed into the load and 4 blocked from the load.

Varying power is developed in the load by varying the "On-time" of the AC current through the load. To detect the number of AC cycles that have been passed to/or blocked from the loads, a synchronization to the mains was required.

A zero crossing detector provides an excellent means of counting the number of AC cycles. The zero-crossing information is obtained from the unsmoothened DC Voltage by noting that the wave form (for a full wave rectifier) is a repeating 100Hz half cycles as shown in fig 3.3.

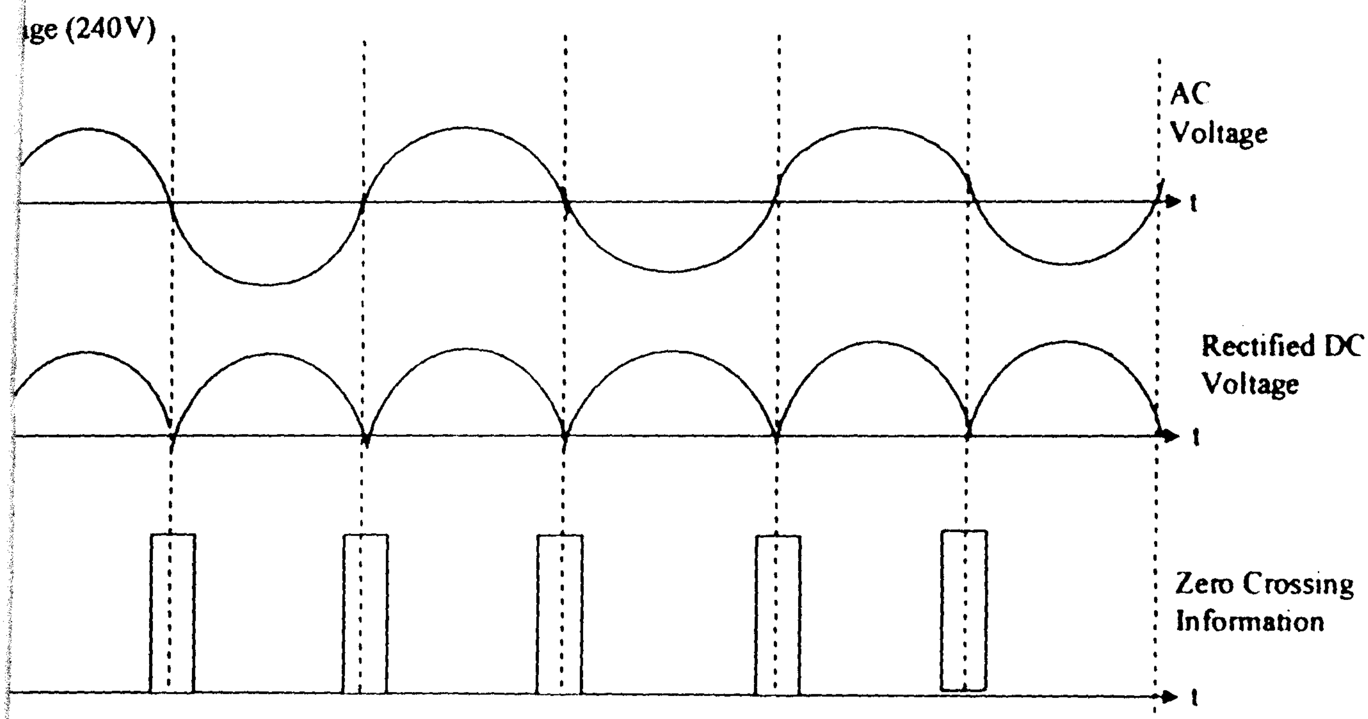

Fig. 3.3: Zero Crossing Information obtained from AC mains

From fig 3.3, a pulse wave form is obtained from the unsmoothened rectified DC voltage wave form. The zero crossing information directly gives the number of half cycles contained in the mains in a time Interval.

A two-stage transistor zero cross detector was used as in fig 3.1. Q_1 was biased by using two-resistor potential divider. The potential divider was made symmetrical so that the transistor Q_1 can come ON at the early portion (or OFF at the falling level) of a half cycle.

For a V_{BE} of 0.7V, and a symmetrical potential divider network, the minimum DC voltage from the rectifier needed to turn on Q_1 is 2 x 0.7V = 1.4V

From $V_{DC} = Vrms\sqrt{2} - 1.4$ $\quad$ $but V_{DC} = 1.4$

$$Vrms\sqrt{2} = 2.8$$
$$Vrms = 2V$$

For complete saturation of Q_1 and Q_2, the resistance values were calculated base on their h_{fe} (Current gain)

Q_1 and Q_{12} have a quoted h_{fe} of 300.

Therefore,

$$V_{CE} = V_{CC} - I_C R_C$$

For $V_{CE} = 0V$

$$V_{CC} - I_C R_C$$

Let $V_{CC} = 15.5V$

$$I_C = \frac{15.5V}{10{,}000\Omega} = 0.00155A$$
$$\approx 1.55mA$$

$$I_C = \beta I_B$$

$$I_B = \frac{I_C}{H_{fe}} = \frac{1.55 \times 10^{-3}A}{300} =$$

$$I_B = 5.17\mu A$$

$$I_B = \frac{V_B}{R_B},\ 5.17\mu A = \frac{0.7}{R_B}$$

$$R_B = 135k\Omega$$

A lower R_B was used to ensure higher base current on low DC voltage, and a $10k\Omega$ resistance was chosen for R_B. Q_2 is an inverter that reverses the phase of the wave form at the collector of Q_1 as shown below:

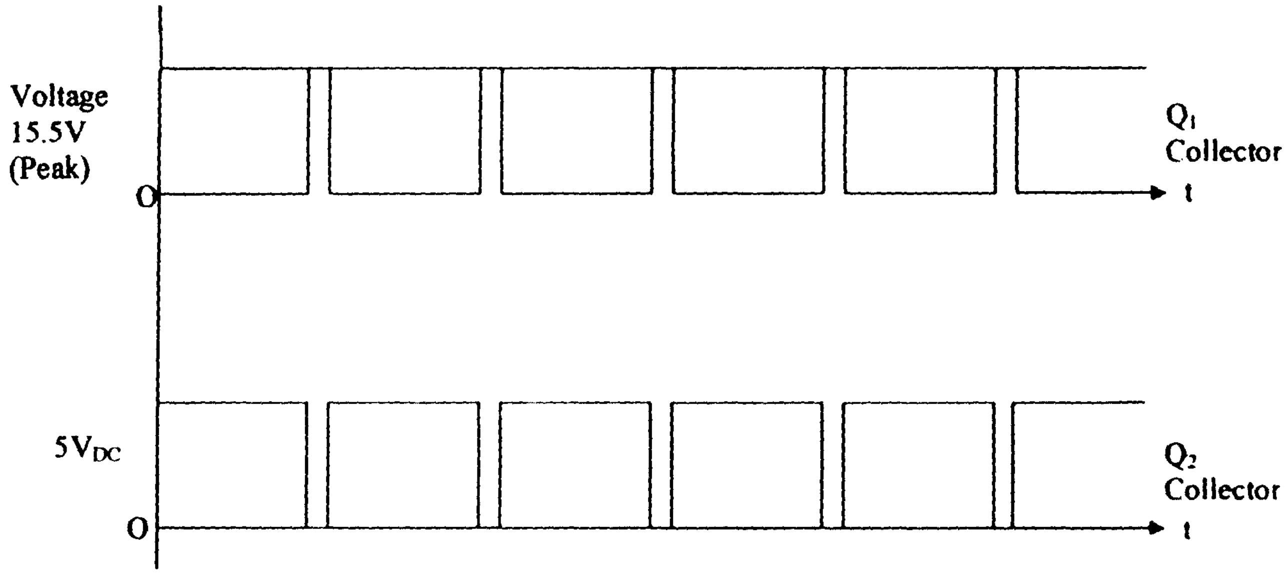

Fig. 3.4 Collector wave form at Q_1 and Q_2

The output into the controller was taken from Q_2 since it is a 5-volt maximum swing logic, and has a falling edge for every half-cycle. The falling edge was used for generating an interrupt used by the timing subroutine.

In the timing routine, the number of half cycles was also counted and was controlled, to vary the average power developed in the fan coil winding.

3.2 8 – BIT ANALOGUE-TO-DIGITAL CONVERTER

Since temperature is an analogue quantity and the microcontroller effecting system control and coordination is a digital device, a translation of the ambient temperature had to be effected.

The translation of the measured temperature variable from the analogue to the digital domain was done using an analogue-to-digital converter.

For ease of computation, and due to the 8-bit register/hardware structure of the controller, an 8-bit converter was selected.

The selection was based on the following criteria:

i. Cost and availability

ii. Fast conversion speed

iii. Wide dynamic range for the input

iv. User-programmable Span voltage

v. Processor -- friendly control interface

An ADC 0804 converter was selected as it met all the above system requirements. The converter has the specifications listed below:

- Compatible with 8080 microprocessor derivatives
- No interface logic needed
- Read access time of 135nS
- Differential analog Voltage Inputs
- Logic Inputs and outputs meets both MOS & TTL Voltage level specifications
- On-Chip clock generator
- 0V to 5V analogue input voltage range with single 5V supply
- No zero adjusts required.

The ADC was interfaced with the LM35 temperature sensor. A reference voltage of 1.28V (2.56V internally) was applied to pin 9 to set up the full scale binary output voltage equivalent to 2.56V input voltage. A one-on-one correspondence between the analogue DC input voltage and the digital output value was established; i.e. 10mV at the input translates to a LSB change in the output.

For example, for an input voltage of 1V/10^{0}C produces a binary output of 100_{10} or 64_{16}.

This is because; the output binary code is a function of the input voltage. For n-bits of resolution, it is approximately expressed by;

$$\text{Binary Output} = \frac{(2^n \ x \ V_{in})}{V_{span}}$$

Where V_{span} = Reference Voltage = 2.56V

n = 8bits

$$\therefore \text{Binary Output} = \frac{2^8 \ x \ Vin}{2.56}$$

$$= 100 \ x \ Vin$$

The one-on-one correspondence allows easy computation of the ambient temperature. The converter was run off a clock source given by the relation.

$$F = \frac{1}{1.1RC}$$

(Resistor) R was chosen as 10kΩ

(Capacity) C was chosen as 100PF

$$F = \frac{1}{1.1x10x10^3 \ x100x10^{-12}}$$

$$F = \frac{1}{1.1 \ x \ 10^{-6}}$$

F = 909090.0Hz

F = 900 kHz

The ADC was controlled via P3.0 and P3.1 through the WRITE and INTR pin. A conversion is initiated by pulsing WRITE low, then high.

Conversion is completed 100μs at the end of which the INTR goes low. The controller reads the INTR logic state on P3.1 and transfers the ADC output to a RAM variable called TEMP-VALUE software processing is then performed on the digital value.

3.3 LM35DZ TEMPERATURE-TO-VOLTAGE CONVERTER

The device is a three-terminal integrated circuit dedicated to temperature monitoring (Sensor). It converts the ambient temperature to voltage using semiconductor properties.

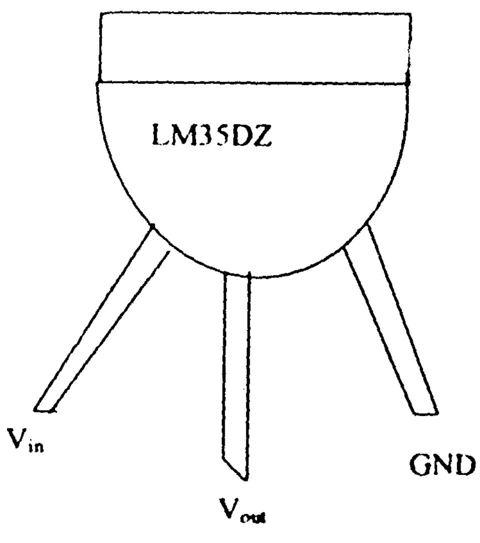

Fig. 3.5: Pin Configuration of LM35DZ

The features of the device are listed below

- Output calibrated directly in centigrade

- Linear + 10.0mV/^{0}C scale factor
- 0.5^{0}C accuracy at 25^{0}C
- Operates from 4V to 30V
- Low impedance output, 0.1Ω for 1mA.
- Rated for full O^{0}C to 100^{0}C range
- Less than 60µA Current gain
- Non Linearity only ± $\frac{1}{4}$^{0}C typical.

The sensor output was connected to the non-inverting input of the 0804. The output was held stable by a 16V100µF capacitor to prevent very rapid change of output DC level. The device was operated on the +5V system logic power supply.

3.4 8-BIT MICROCONTROLLER (89S51)

A 89S51 9-bit microcontroller was used for coordinating system operation.

The controller;

- Directs the ADC's operation
- Scans the keypads for manual speed selection
- Manipulates the ADC output to extract the speed information
- Displays the fan speed on a 7-segment display
- Counts the number of AC cycles.

Fan speed regulation was effected using a look- up table to convert the ADC output to the corresponding speed level. The ADC output was used to look-up the corresponding value to load in the speed control register.

A 256-byte table was used for this, since an 8-big ADC was used. The value read from the table was used to compute the fan speed via pulse width modulation.

The controller effected the speed regulation via the zero-crossing input from the zero crossing detector (ZCD). The output of the ZCD was an 100Hz square waveform.

3.4.1 PWM OPERATION

For a 50Hz mains frequency, the period is 20ms. The ZCD produces a pulse every 10ms.

10AC cycles were monitored; hence, a maximum OFF-TIME of 200ms or a minimum ON-TIME of 200ms provided the necessary control.

The PWM software routine uses two registers to specify the ON-TIME and the OFF-TIME. The combined total of the two registers always yields 200ms.

Accurate time base generation was not needed since the speed control was locked on to the mains frequency, hence the system is adaptive.

Assuming a temperature level provides a read of 4 from the look-up table, the ON-TIME register is loaded with (4 x 2) = 8, and the OFF-TIME loaded with (10 – 4) x 2 = 12. The triac is commanded ON for 4 half cycles (80ms); theh is, (8 x 10ms ZCD output), and OFF for 6 half cycles (120ms) i.e. (12 x 10ms ZCD output).

The variable duty cycle control provided an easy means of adjusting the average power developed in the coil winding, hence the fan speed. For maximum fan speed, the triac was simply turned on; at minimum fan speed, it was turned off.

The lower temperature limit for fan turn off was fixed at 24°C; the upper limit was fixed at 31°C; at 24°C, the fan is OFF, at 31°C, the fan is full on and therefore was at maximum speed.

A manual speed setting was also provided on the unit. A pair of up/down button was provided. Adjusting the buttons disables automatic speed control.

A return to automatic speed control can be effected by a system reset (Via a RESET Switch) since the unit powers up in the auto mode by default.

The selected speed was displayed on a single digit common-anode seven segment display. Bitmapping was used to generate the necessary signals for controlling the segments. The negative - true 7-segment codes for the digits 0-9 were loaded from memory and sent to port 0 to which the display was connected.

3.5 POWER TRIAC

A BT139 power triac was used to switch the current through the load ON or OFF.

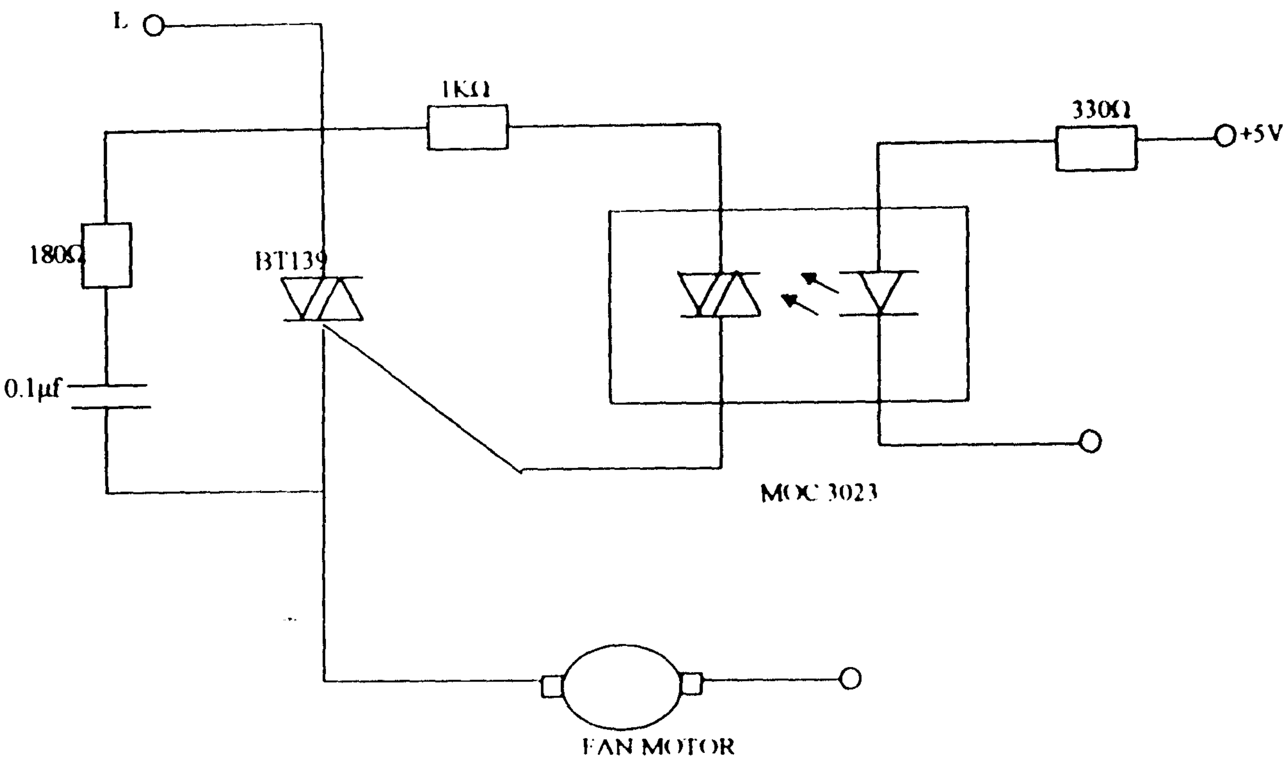

Fig. 3.6 Power Triac System Interface

The BT139 was interfaced with the systems shown in fig 3.6. Electrical isolation was effected using an MOC3023. The MOC3023 opto-triac allowed the 24OV AC supply to be modulated by the +5V controlled system.

The MOC3023 embodies an integral triac with a light - sensitive gate, and an infra red light emitting diode with the diode forward-biased, the opto-triac is turned ON and current flows into the gate of the power triac. The power triac fires and current flows through the load.

By design, a triac turns OFF at the zero crossing of the half cycles. However if gate current still exists, it immediately switches back ON.

AC power modulation was realized by exploiting this property of self-turn off. The zero crossings of the AC wave forms were used as the switching points by the control software.

3.6 SYSTEM SOFTWARE

The system software is an endless loop. The system defaults to the auto mode of operation at power up. The flow chart is diagramed below:

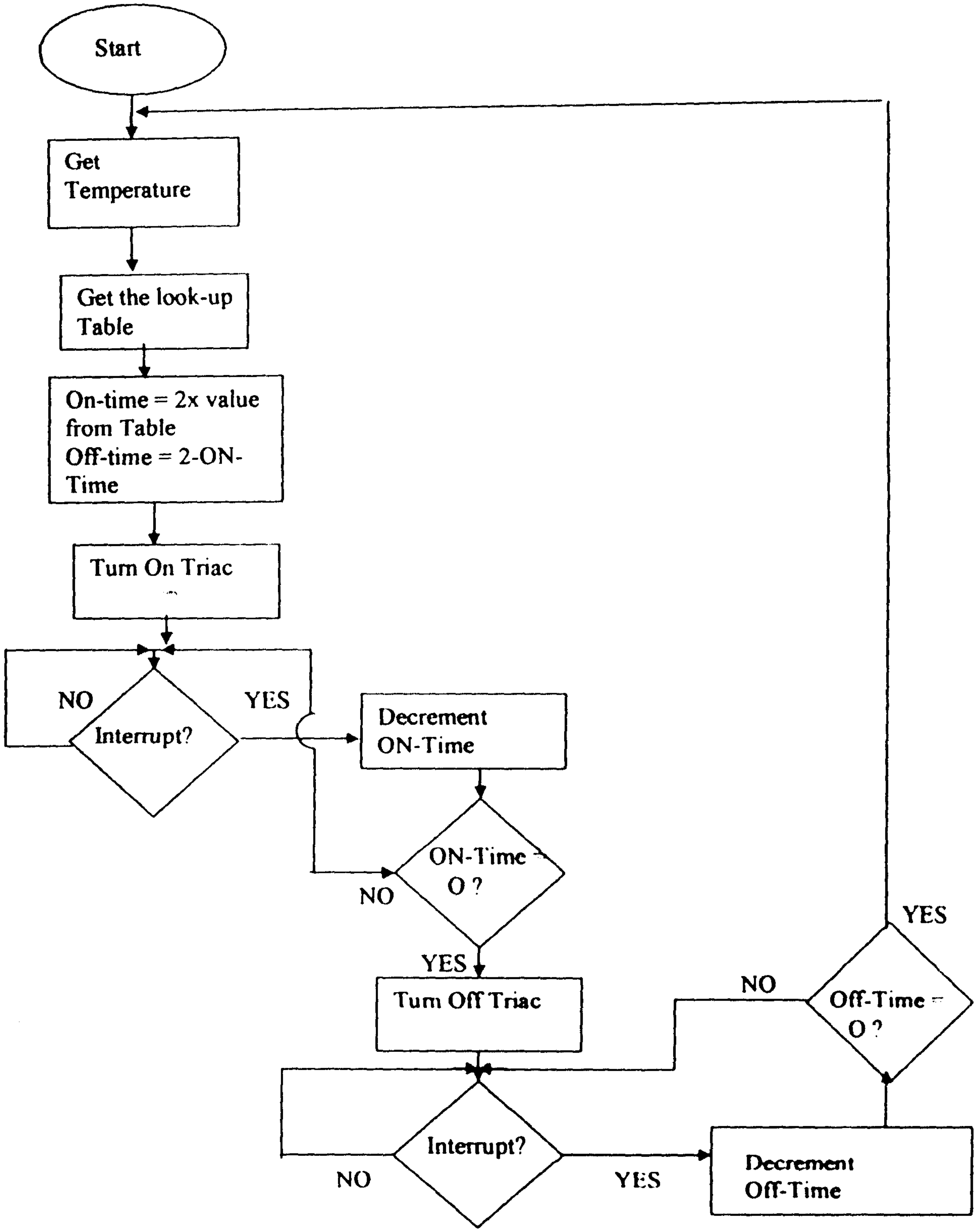

Fig. 3.7 Flowchart of the Program

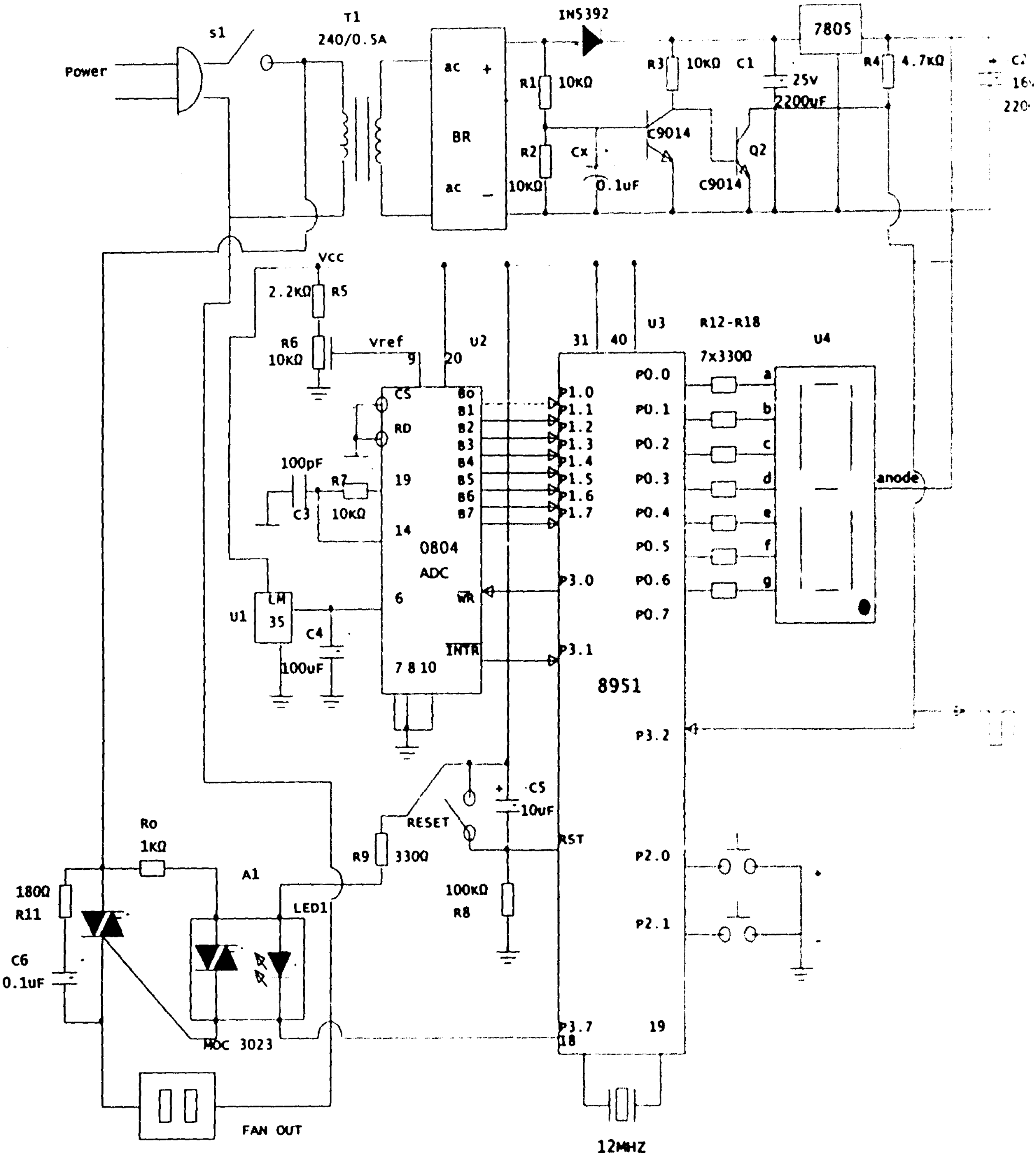

Figure 3.8 Circuit Diagram of a Microcontroller based temperature controlled Fan speed regulator with a digital display

CHAPTER FOUR

TEST, RESULT AND DISCUSSION

4.1 TESTS

The physical realization of the project work is very vital. This is where the fantasy of the whole idea meets reality. The work at this stage is not just on paper but as a finished hardware system. The first step in the construction of the project was the purchase of the needed component. They were properly and independently tested for malfunction or defect.

The different units for example the power section were simulated using multisim 9 circuit simulator. The circuit was directly soldered on Vero board, afterwards the circuit connection were properly tested for any wrong positioning and was set for real functionality test.

The test was conducted by connecting a standing fan to the output of the control unit (fan out) then connecting the set up to the AC mains. The display was on, showing the corresponding speed of the equivalent temperature of the room at that particular point in time. The manual plus (+) button was then pressed, which increases the speed of the fan while displaying it, when manual minus (-) decreases the speed correspondingly.

Also an ice block and a heater were provided. When it was returned in the auto mode (reset), an ice block was brought near the temperature sensor (LM 35) for it to sense the temperature as a lower one. The speed of the fan drops immediately. Equally, a heater was heated to an appreciable temperature and was brought near the sensor, the device senses it as a higher temperature thus, increases the speed of the fan automatically. The different tests were carried out several times to check the response of the system.

4.2 RESULT AND DISCUSSION

It was observed that both the control unit and connecting fan responded to the signal (pulses) from the system (software) controller

The system defaults to the auto mode of operation at power up The highest observed speed Corresponds to digit display 9 while the lowest was digit 0 (fan off)

The lower temperature limit for fan to turn off was fixed at 24°C, while the upper limit fixed at 31°C. Any temperature below this preset value (24°C) reads a zero speed and therefore fan will be completely off

Similarly, at any temperature above 31°C displays the maximum speed (9) The aim of this project work was therefore realized

The figure below shows different tests being carried out at several temperature levels

Haven known that temperature sensor (LM35) senses at 10mV/1°C, the following results were obtained;

Table 4.0 Result obtained

SAMPLE	TESTS	TEMPERATURE (°C)	DISPLAYED SPEED LEVEL	VOLTAGE (V)
ROOM TEMPERATURE	MORNING	26°C	3	2.6V
	AFTERNOON	31°C	9	3.1 V
	EVENING	28°C	5	2.8V
HEATER	TEMPERATURE1	29°C	6	2.9V
	TEMPERATURE2	37° C	9	3.7V
ICE BLOCK	TEMPERATURE1	20°C	0	2.0V
	TEMPERATURE2	24°C	1	2.4V

Fig 4.0 The casing

Fig 4.1 The construction

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The project demonstrated an automatic way to regulate the fan speed as a direct function of the ambient temperature around the sensing device (LM35).

It worked efficiently with a temperature range of 24°C to 31°C which corresponds to a speed of 0 to 9 respectively. The system has been tested and was found to meet the expected results.

There were few challenges while working on the project which required reasoning and researching, most especially in the programming aspect.

Also, some components were destroyed due to wrong connections but was rectified and replaced.

The project merely shows the importance of digital electronics in control applications.

5.2 RECOMMENDATION

This project work could be further worked upon in future and enhanced, to be of more benefits to the society. Thus, the following are recommended;

- A circuit to handle automatic switching in response to presence or absence of people in the room.
- Features such as alarm could be incorporated into the design for warning features.
- A remote controlled circuit for the manual reset is recommended also.

By adjusting the design depending on the specified range of the temperatures needed, other areas of application are;

- Automatic engine temperature control.
- The control of central heating system.
- Control of temperature in an incubator.

REFERENCES

[1] Datasheet Search System [online]; ©2000-2006 Fan history, Available at

http://www.datasheetachieve.com/datasheet.php?article486227

[2] Maximum.ic [online]; ©1998-2006 Fan speed control, Available at

http://maximum.ic.com/article/view-article.cfm

[3] Contreolres [online]; ©2007 Power consumption, Available at

http://www.contreolres.com/ac.htm

[4] Microchip [online]; ©2008 Caustic noise reduction, Available at

http://www.microchip.com/download/en/appnotes

[5] Wikipedia [online]; ©2007 History of temperature, Available at

http://EN.wikipedia.org/wiki/temp

[6] Brannan [online]; ©2006 History of temperature, Available at

http://www.brannan.co.uk/weather/story.html

[7] K.M Leatherman, Automatic controls for heating and air conditioning, principles and application, vol 15,*Pergamon press*, pp9,15,23-25

[8] Landis Fred, Temperature, Microsoft Encarta Premium, 2006

[9] Adeyi Bashir, Design and Construction of a Temperature Induced Automatic Room Fan Regulator, 2006, pp30

[10] Kasai A.E, Design and construction of a Temperature Sensing Fan regulator with Speed Setting Remote Control, 2003, pp31

[11] Theraja B.L, Theraja A.K, A text book of electrical technology Ed 21st, *Nirja construction and development co.ltd, Ram Nagar*, 1994, pp2166

[12] Wikipedia [online]; ©2005 89S51microcontroller, Available at

http://en.wikipedia.org/wiki/89S51microcontroller

[13] Wikipedia [online]; ©2007 ADC0804, Available at

http://en.wikipedia.org/wiki/Analogue-to-digital-converter

[14] Goggle Search System [online]; ©2007 ADC0804, Available at

http://www.ece.Drexel.edu/Courses/ECEL303AD

[15] Paul Horowitz and Winfield Hill, The art of Electronic, *Cambridge University press*, pp338ff, 988

[16] Thomas E.Newman, Electricity and Electronics, 1995, pp88ff

[17] Giorgio Rizzoni, Principle and Application of Electrical Engineering Revised 4th Edition, *New York McGraw hills*, pp713-715

[18] Dennis W.H, Electronics Components and system, *Butterworth and co pub.Ltd*, 1982, pp237, 242,244

APPENDIX 1

TEMPERATURE CONTROLLED OPERATIONAL MANUAL FOR SAFETY

- It operates in the temperature range from 24°C to 31°C.
- Temperature sensor connected externally to the device, is to sense the temperature of the surrounding.
- Always disconnect the fan when not in use.

PRICED BILL OF COMPONENTS

NO	Materials	Quantity	Unit rate (Naira)	Total cost (Naira)
1	Resistor	19	10	190
2	Capacitor	7	10	70
3	Diode	1	10	10
4	7805 (regulator)	1	70	70
5	Bridge rectifier	1	40	40
6	8951(microcontroller)	1	180	180
7	0804 (ADC)	1	150	150
8	LM35 (sensor)	1	80	80
9	BT139 (triac)	1	120	120
10	MOC3023 (opto-triac)	1	100	100
11	7-segment display	1	50	50
12	Switches	4	50,20	110
13	Lead	4(yards)	10	40
14	Connecting wires	3(yards)	10	30
TOTAL				1240

APPENDIX 2

```
INCLUDE 89C51.MC

ON_TIME DATA 08H
OFF_TIME DATA 09H
SPEED DATA 0AH
ADC_PORT EQU P1
TRIAC_DX BIT P3.7
MANUAL_PLUS BIT P2.0
MANUAL_MINUS BIT P2.1
MANUAL_ON BIT 00H
ZERO_SPEED BIT 01H
MAX_SPEED BIT 02H
LOAD_OFF_TIME BIT 03H
stack  EQU 60h
adc_write BIT p3.0
adc_intr BIT p3.1
display_port EQU p0
TEMP DATA 0CH


ORG 0000H
LJMP START_UP


ORG 0003H
LJMP SET_SPEED


ORG 0030H
START_UP:                    CLR EA
                             MOV SP,#STACK
                             ACALL SYS_INIT

mainloop:                    JB MANUAL_ON, GO_MANUAL
LOOP_1:                      ACALL GET_TEMP
                             MOV DPTR,#SPEED_tABLE
                             MOVC A, @A+DPTR
                             MOV SPEED,A

GO_MANUAL:                       MOV A, SPEED
                             MOV DPTR,#SEG_tABLE
```

```
                MOVC A,@A+DPTR
                MOV DISPLAY_PORT,A
                MOV A,SPEED
                JZ SET_ZERO
                XRL A,#9
                JZ SET_MAX
                CLR ZERO_SPEED
                CLR MAX_SPEED
                MOV A, SPEED
                CLR C
                RLC A
                MOV ON_TIME,A
                MOV A, #20
                CLR C
                SUBB A, ON_TIME
                MOV OFF_TIME,A
                SJMP SCAN_KEY

SET_ZERO:       CLR MAX_SPEED
                SETB ZERO_SPEED
                SJMP SCAN_KEY

SET_MAX:        SETB MAX_SPEED
                CLR ZERO_SPEED

SCAN_KEY:       JB MANUAL_PLUS,SCAN_KEY2
                ACALL SET_MANUAL_PLUS
                ACALL DELAY_key

SCAN_KEY2:          JB MANUAL_MINUS,MAINLOOP
                ACALL SET_MANUAL_MINUS
                ACALL DELAY_key
                JMP MAINLOOP

SET_MANUAL_PLUS:    MOV A, SPEED
            XRL A, #9
            JZ NO_INC
```

```
                        INC SPEED
                        SETB MANUAL_ON
NO_INC:                 RET


SET_MANUAL_MINUS:           MOV A, SPEED
                        JZ NO_DEC
                        DEC SPEED
                        SETB MANUAL_ON
NO_DEC:                 RET


SET_SPEED:              CPL p3.6
                        JB ZERO_SPEED, TURN_FULL_OFF
                        JB MAX_SPEED, TURN_FULL_ON
                        JB LOAD_OFF_TIME, GO_LOAD_OFF
                        DJNZ R6, EXIT
                        SETB TRIAC_DX
                        MOV R6, OFF_TIME
                        SETB LOAD_OFF_TIME
EXIT:                   RETI


GO_LOAD_OFF:            DJNZ R6, EXIT
                        CLR TRIAC_DX
                        MOV R6,ON_TIME
                        CLR LOAD_OFF_TIME
                        RETI


TURN_FULL_OFF:          SETB TRIAC_DX
                        RETI


TURN_FULL_ON:           CLR TRIAC_DX
                        RETI


delay_key:              MOV R2,#50
do_that:                ACALL delay
                        DJNZ R2, do_that
                        RET
```

```
GET_TEMP:  ACALL CONVERT_TEMP
           MOV TEMP,A
           ACALL delay
           ACALL delay
           ACALL delay
           ACALL delay
           ACALL CONVERT_TEMP
           ADD A, TEMP
           CLR C
           RRC A
           ACALL delay
           ACALL delay
           ACALL delay
           ACALL delay
           RET


DELAY:     MOV R3,#33
reload: MOV R4,#0
AGAIN:     DJNZ R4, AGAIN
           DJNZ R3,reload
           RET


convert_Temp:       CPL p3.5
                    CLR adc_Write
                    NOP
                    NOP
                    NOP
                    NOP
                    SETB ADC_wRITE
                    MOV R1,#0
                    DJNZ R1,$
                    ;JB adc_intr, $
                    MOV A, adc_port
                    RET
```

```
Seg_Table: DB
11000000b,11111001b,10100100b,10110000b,10011001b,10010010b,10000010b,11111
000b,10000000b,10010000b


SYS_INIT:               SETB TRIAC_dX
                        SETB P3.2
                        SETB ADC_wRITE
                        SETB ADC_INTR
                        MOV DISPLAY_PORT,#0FFH
                        SETB MANUAL_PLUS
                        SETB MANUAL_MINUS
                        MOV TCON,#00000001b
                        MOV IE,#00000001b
                        MOV SPEED,#0
                        CLR MANUAL_ON
                        SETB ZERO_SPEED
                        CLR MAX_SPEED
                        MOV R6,#2
                        MOV on_time,#2
                        MOV off_time,#18
                        SETB LOAD_OFF_TIME
                        SETB EA
                        RET


table: DB 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
       DB 0,0,0,1,2,3,4,5,6,7,8,9,9,9,9,9,9,9,9,9,9
       DB 9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9
       DB 9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9
       DB 9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9
       DB 9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9
       DB 9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9
       DB 9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9
       DB 9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9
       DB 9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9
       DB 9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9
       DB 9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9
       DB 9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,9,

       end
```