DESIGN AND CONSTRUCTION OF MICROCONTROLLER-BASED AUTOMATIC SCHOOL BELL

BY

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MATRICULATION NUMBER:

2004/18777EE

ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT

SCHOOL OF ENGINEERING AND ENGINEERIG TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

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A FINAL YEAR PROJECT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE AWARD OF THE BACHELOR OF ENGINEERING (B. ENG.) DEGREE IN ELECTRICAL AND COMPUTER ENGINEERING

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DEDICATION

This project work is solely dedicated to the Holy prophet Mohammed (S.A.W.), my parents and you who look forward for me to achieve an optimal happiness in life.

DECLARATION

I Ahmed Ibrahim, declare that this work was done by me and has never been presented elsewhere for the award of degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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ABSTRACT

This project presents the design and construction of an Automatic School Bell that can be used both in Primary and Secondary Schools. The design works on the principle of timing programmed in microcontroller chip. It provides ten (10) different schedules each with a total number of eight (8) periods and breakfast after the fourth period. An emergency ringing is included and it is active for every schedule selected. The features included are: the time-select switches, microcontroller, LED indicators, switching transistor, relay, DC motor and the Bell.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 Introduction

In the world where Science and technology is improving almost every day, most of the present day work activities are not manually operating again. They are automatically carried out by themselves with use of electronic components. This project, which is the Design and Construction of Automatic School Bell, is another electronic project that steps further in the quest for the improvement of Man's living condition in both Primary and Secondary Schools where a student, known as Time-Keeper is assigned for the ringing of the bell.

A bell is signal in a School, either a real bell, a distributed ringer or a sound heard over the intercom that tells the students when it is time to go to class in the morning and when it is time to change classes during the day. Typically, the first bell tells the students that it is time to report class [1].

The bell is an important instrument in both Primary and Secondary Schools and even in the industries and other business where the bell timer plays a critical role in running the day [2]. Bells are also associated with clocks indicating the hour by ringing. Clock towers or bell towers can be heard over long distances which was especially important in the time when clocks were too expensive for wide spread use. A bell is a simple sound-making device. The bell is a percussion instrument and an idiophone. Its form is usually an open ended hollow drum which resonates upon being struck. The striking implement can be a tongue suspended within the bell known as a clapper, a small free sphere enclosed within the body of the bell, or a separate mallet [3].

Bell are usually made of cast metal, but small bells can also be made from ceramic or glass. Bell can be of all sizes: from tiny dress accessories to Church bells weighing tons. The ringing of bells known as bell ringing, and such a bell produces a very loud, clear tone. If the bell as cast, it is called a "maiden bell" while "tuned bells" are worked after casting to produce a precise note. The traditional metal for these bells is a bronze of about 20% tin. Known as bell metal, this alloy is also the traditional alloy for the finest Turkish and Chinese cymbals. Other materials sometimes used for large bells include brass and iron. The process of casting bells is called bell making or bell founding [3].

1.2 Project Aim and Objective

The main aim of this project is to Design and Construct an Automatic School Bell for both Primary and Secondary Schools, and even for some areas of application where timing is needed. In so doing, materials that are locally available have been used to design a reliable automatic School bell system that facilitates easy operation of the bell automatically.

1.3 Features of the Project

This project is design in such a way that it has the following features:

(i.) The bell is played at preset times.

(ii.) No need to assign a person for ringing bell every time.

(iii.) There is accuracy to timings.

(iv.) No manual intervention.

(v.) Man power and money is saved.

(vi.) Provides ten (10) different possible schedules each with emergency

1.4 Limitation

Usually there is limitation for everything in this world; nothing is absolutely 100% efficient. Therefore, this project design has limitation, that is, the range at which it operates. It provides timings for maximum number of eight (8) subjects per day with breakfast period. It has ten (10) different time selections per subject, each with breakfast duration after the fourth period. Each selection has an emergency ringing. It does not operate outside this limit.

CHAPTER TWO

LITERATURE REVIEW

2.1 History of the Bell

Bells were known in China before 2000 BC and in Egypt, India, Greece, Rome, and other ancient cultures. From earliest times they were used as signaling devices, as ritual objects, and as magical, often protective, amulets (often hung in doorways or around the necks of animals). The use of bells in churches spread through Europe in the 6th to 11th centuries and were first used in Eastern Christian churches in the 9th century [4].

The earliest metal bells were apparently hammered into a cup shape from a flat piece of metal. When the process of casting metal was discovered, many bells were cast of bronze. The casting of bells declined in late antiquity, and hand bells of the cowbell type came into use; these were made of thin metal plates bent into rectangles and fastened with rivets. About AD 800 the casting process resurfaced, making possible the manufacture of large tuned bells [4].

By about 1400 the characteristic campaniform shape of Western bells had evolved: square-shouldered, with straight or slightly concave sides (the waist), flaring out and thickening near the rim (the sound bow). This stronger shape also improved the tone, and in the 15th to 18th centuries bell-makers in the Low Countries specialized in producing bells so well tuned that they could be played in harmony. In England, sets of somewhat differently tuned bells were rung in complicated permutations of a standard sequence, a process known as change ringing [4].

A type of iron hand-bell was developed in sub-Saharan Africa and remains an integral part of many African musical traditions. Because the hand-bells typically have no clapper, they are struck with a beater to produce sounds. The sharp, penetrating sound of the iron hand-bell can also be heard in the African-influenced music of Latin America [4].

2.1.1 Hand Bell

A hand bell is a bell designed to be rung by hand. To ring a hand bell, a ringer grasps the bell by its slightly flexible handle-traditionally made of leather, but often now made of plastic, and move the wrist to make the hinged clapper inside the bell strike [5]. The first tuned hand bells were developed by brothers Robert and William Cor in Aldbourne, Wiltshire, England between 1696 and 1724. The Cor brothers originally made latten bells for hame boxes, but for reasons unknown, they began tuning their bells more finely to have an accurate fundamental tone, and fitted them with hinged clappers that only move in one plane [5].

Hand bells were first brought to the United States from England by Margaret Shurcliff in 1902. She was presented with a set of ten (10) hand bells in London by Arthur Hughes, the general manager of the White-Chapel Bell Founding after completing two separate $2\frac{1}{2}$ hours change ringing peals in one day [5].

2.1.2 Some other Bells in Existence

i. The Tsar Kolokol bell is the largest bell still in existence. It weighs 160 tones. It is casted in 1733, in Moscow, Russia [3, 4].

ii. The world peace bell was the largest functioning swinging bell until 2006. It is located in Newport, Kentucky, United States, cast by Paccard of France. The bell itself weighs 66,000Ib while with clapper and supports the total weight which swings when the bell is tolled is 89,390Ib [3].

iii. The Liberty bell is an American bell of great historic significance, located in Philadelphia, Pennsylvania. It previously hung in independence hall and was rung on July4, 1776 to mark American independence [3].

iv. Little John, named after the character from the legends of Robin Hood, is the bell within the Clock Tower of Nottingham Council House. It is the deepest bell in the United Kingdom and its chimes are said to be heard over the greatest distance of in the UK [3].

v. Big Ben is the hour bell of the great clock in St. Stephen's Tower at the Palace of West minister, the home of Houses of Parliament in the United Kingdom [3].

2.2 Background Information

A School bell is the bell that is mostly use in both Primary and Secondary schools which serve as the sound or alert signal to both students and staff. A School bell rang out for the first time since before the Second World War at Stanton Peak Primary School, England [6]. Many of the bells listed above are ringing manually; therefore there is need for these bells to be rung automatically without human intervention. Hence, that is the aim and objective of this project.

The design and construction of this project is achieved by the use of electronic components which serve as the mechanism behind the operation of the School bell. The major component in this project is microcontroller which coordinates and controls the overall activities of the other components. This can better be understood by referring to the fig.2.1. This is an effective and useful project for educational institutions [7]. In most Schools and Colleges, the Timekeeper rings the bell after every period (usually of 40-min duration). The timekeeper has to depend on his wrist watch or clock, and sometimes he can forget to ring the bell in time [7].

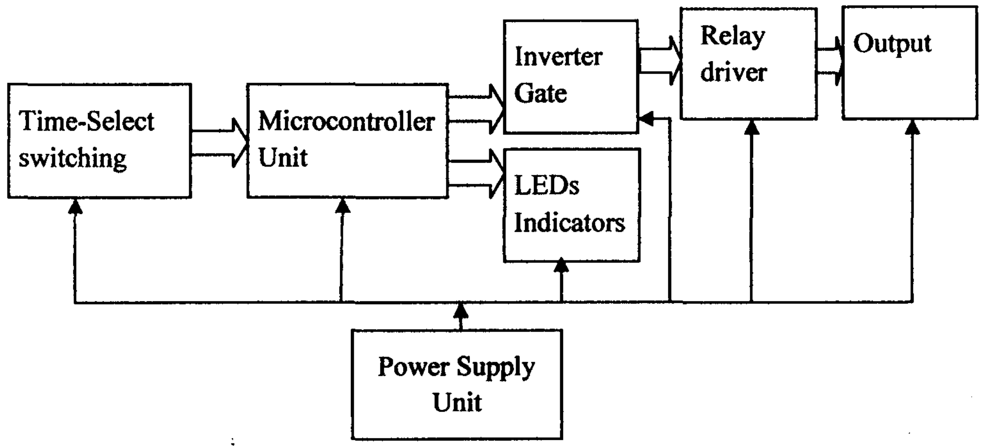


Figure 2.1 Block Diagram of the Automatic School Bell

(A.) Power Supply

Power supplies are an essential part of all electronic systems from the simplest to the complex [8, 10]. A basic power supply consists of a transformer, a rectifier, a filter and a regulator [8, 9, 10, 11, 12, 14, 18]. A power supply filter greatly reduces the fluctuation in the output voltage of a half-wave or full-wave rectifier and produces a nearly constant-level dc voltage. Filtering is necessary because electronic circuits required a constant source of dc voltage and current to provide power and biasing for proper operation. Filtering is accomplished using capacitors [8, 9, 10, 14], as you will see in the next chapter. Voltage regulation is usually accomplished with integrated circuit voltage regulators. A voltage regulator prevents changes in the filtered dc voltage due to variation in line voltage or load [8, 9, 10, 11, 12, 14, 18].

(B.) Time-select Switching Unit

This project is design to provide maximum number of ten different schedules. This unit allow for the selection of the schedule suitable for every School. The unit consists of resistors and normally opened switches. Each of the switches represents a single schedule which can be chosen by individual. When any of these switches is activated, it directs the microcontroller to carry out some specific task as programmed internally.

(C.) Microcontroller

A **microcontroller** (also microcontroller unit, MCU or µC) is a small computer on a single integrated circuit consisting of a relatively simple CPU combined with support functions such as a crystal oscillator, timers, watchdog, serial and analog I/O etc. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a, typically small, read/write memory [15].

Microcontrollers are designed for small applications. Thus, in contrast to the microprocessors used in personal computers and other high-performance applications, simplicity is emphasized. Some microcontrollers may operate at clock frequencies as low as 32kHz, as this is adequate for many typical applications, enabling low power consumption (milliwatts or microwatts). They will generally have the ability to retain functionality while waiting for an event such as a button press or other interrupt; power consumption while sleeping (CPU clock and most peripherals off) may be just nanowatts, making many of them well suited for long lasting battery applications. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, remote controls, office machines, appliances, power tools, and toys. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes [15].

The first single chip microprocessor was the 4 bit Intel 4004 released in 1971, with other more capable processors available over the next several years. These however all required external chip(s) to implement a working system, raising total system cost, and making it impossible to economically computerize appliances [15].

The first computer system on a chip optimized for control applications - microcontroller was the Intel 8048 released in 1975, with both RAM and ROM on the same chip. This chip went on to be found in over a billion PC keyboards, and numerous applications [15, 21]. The whole story has its beginnings in the far 80s when Intel launched the first series of microcontrollers called the MCS 051. Even though these microcontrollers had quite modest features in comparison to the new ones, they conquered the world very soon and became a standard for what nowadays is called the microcontroller [21]. Most microcontrollers at this time had two variants. One had an erasable EEPROM program memory, which was significantly more expensive than the PROM variant which was only programmable once [15, 21].

In 1993, the introduction of EEPROM memory allowed microcontrollers (beginning with the Microchip PIC16x84) to be electrically erased quickly without an expensive package as required for EPROM, allowing both rapid prototyping, and In System Programming [15].

The same year, Atmel introduced the first microcontroller using Flash memory. Other companies rapidly followed suit, with both memory types. Cost has plummeted over time, with the cheapest microcontrollers being available for well under $0.25 in 2009 , and 32 bit microcontrollers under $5. Nowadays microcontrollers are low cost and readily available for hobbyists, with large online communities around certain processors [15]. Therefore, the microcontroller, after the appropriate switch has been activated, process internally and give out the outputs to both relay driver and the led indicators.

(D.) LED Indicators

Light-emitting diodes (LEDs) are good devices to visually display a HIGH (1) or LOW (0) digital state [13]. Thus they are used here to mark the starting and the end of the School hours.

(E.) Inverter (NOT) Gate

In contrast to analog circuits, which utilize continuous variables, in digital circuits the electrical variables are usually restricted to two discrete values, with reasonable tolerances for component variations and noise. The two values are arbitrarily designated as state 0 and 1. Complicated systems can be built by properly arranging large numbers of a few elementary circuits, called logic gates, which implement desired logical operations of the 0 and 1 states. Combinational logic systems consist of gates with output that depend on the inputs present at the time [11].

The logic gates are the basic building blocks for forming digital electronic circuitry. A logic gate has one output terminal and one or more input terminals. Its output will be HIGH (1) or LOW (0) depending on the digital level (s) at the input terminals. Through the use of logic gates we can design digital systems that will evaluate digital input levels and produce a specific output response based on that particular logic circuit design [13]. NOT gate is one of these logic gates. NOT gate only has single input and single output. The operation of NOT gate is simple and is defined as follows: The output is HIGH if input is LOW and LOW if input is HIGH [11, 13,16,19]. Therefore NOT gate will allow the relay driver to trigger the bell for the period of time that the microcontroller output remains high. Thus, this gate amplifies current supplied to the driver.

(F.) Relay Driver

This consists of transistor and relay. A transistor is used to establish the current necessary to energize the relay in the collector circuit [14]. The bipolar transistor is a very commonly used switch in digital electronic circuits. It is three-terminal semiconductor component that allows an input signal at one of its terminals to cause the other two terminals to become a short or an open circuit [13]. Also in [14] the application of transistor is not limited solely to the amplification of signals. Through proper design transistors can be used as switches for computer and control applications. Transistor can be used to: switch currents, voltage and power; perform digital logic functions; and amplify time-varying signals [9, 12]. The output from the microcontroller is connected to the base of the transistor. With no input at the base of the transistor, the base current, collector current and coil current are essentially 0A, and the relay sits in the unenergized state (normally open, NO). However, when a positive pulse (NPN type) is applied to the base, the transistor turns on, establishing sufficient current through the coil of the electromagnet to close the relay [14], thereby triggering the output (Bell). Ideally, at turn-off the current through the coil and the transistor will quickly drop to zero, the arm of the relay will be released, and the relay will simply remain dormant until the next 'ON' signal [14].

CHAPTER THREE

DESIGN AND CONSTRUCTION

As understood from the chapter two, section 2.2; there is need to analyze each block of the project for proper design and implementation. Therefore, this design can be done as follows:

3.1 Design of Power Supply Unit

Most of the electronic devices and circuits required a dc source for their operation [9]. The dc power supply converts the standard 230V, 50Hz ac available all wall outlets into a constant dc voltage. It is one of the most common electronic circuits that you will find. The dc voltage produced by power supply is used to power all types of electronic circuits, such as television receivers, computers and laboratory equipments [8]. A typical dc power supply consists of five stages as shown in fig. 3.1. Thus, the ICs and other components used run on a power supply of 5V and 12V, hence the supply must be regulated to prevent fluctuation in voltage level.

Fig. 3.1 A typical dc power supply block diagram [8, 9, 14]

These blocks can be briefly explained as follows:

(i.) **Transformer:** its job is either to step up or (mostly) step down the ac supply voltage to suit the requirement of the solid state electronic devices and circuits fed by the dc power supply [9].

(ii.) **Rectifier:** it is a circuit which employs one or more diodes to convert ac voltage into pulsating dc voltage [8, 9, 10, 12, 13]. A rectifier can be either a half-wave rectifier or full-wave rectifier [8]. In this design a full-wave rectifier was employed.

(iii.) **Filter:** the function of filter of this circuit element is to remove the fluctuations or pulsations (called ripples) present in the output voltage supplied by the rectifier [9]. This is done by connecting a capacitor filter to the rectifier.

(iv.) **Voltage Regulator:** its main function is to keep the terminal voltage of the dc supply constant even when the ac input line voltage to the transformer, or the load varies [8, 9, 18].

(v.) **Load:** the load block is usually a circuit for which the power supply is producing the dc voltage and load current [8].

Therefore, the complete circuit diagram of the power supply is as shown below.

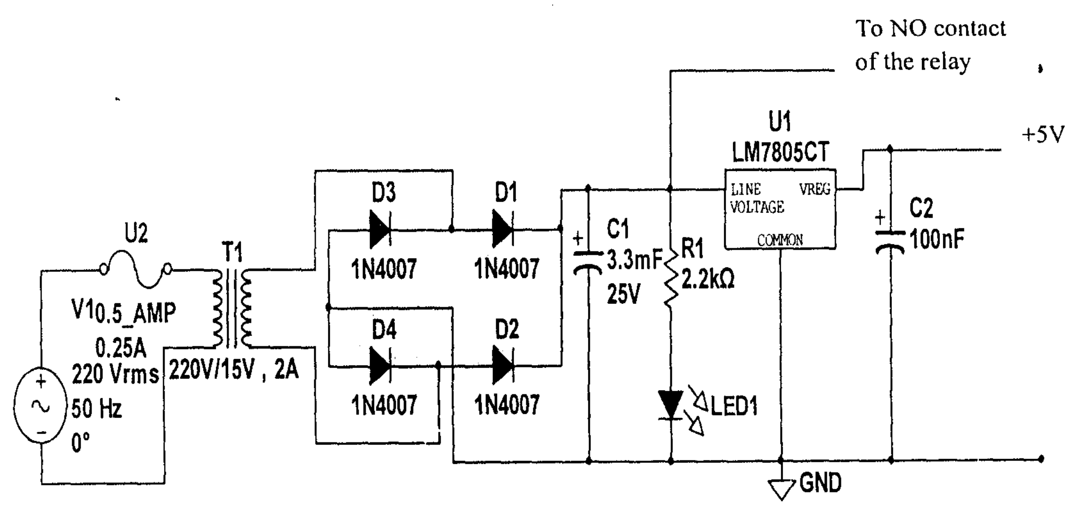


Fig 3.2 Circuit Diagram of Power Supply Unit

The main voltage of 220V is stepped down by a 220V/15V, 2A transformer. It is then rectified by full wave bridge diode rectifier. The waveform at this stage has no negative component, but a lot of ripples. Smoothing capacitors are needed to reduce the ripple to an acceptable level. The resulting ripple voltage (dv) can be calculated by considering the waveforms given in fig. 3.3.

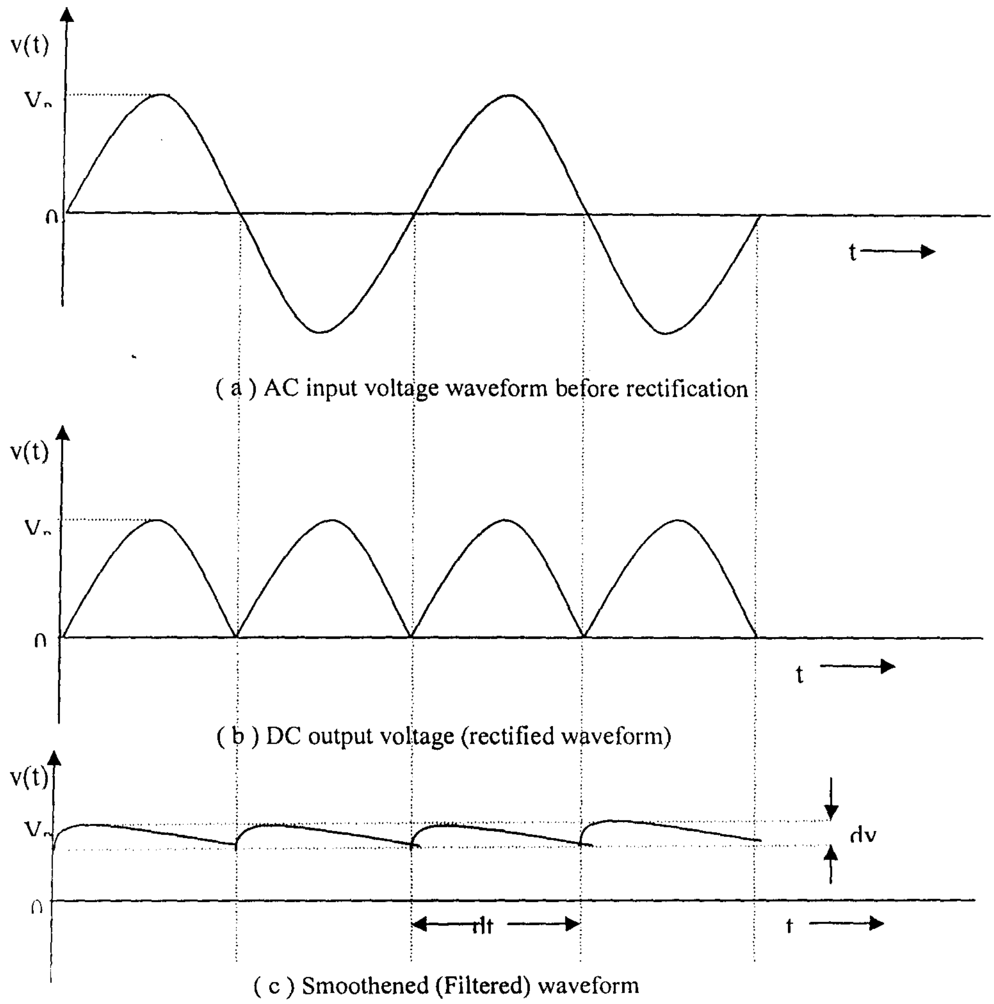


Fig. 3.3 Power supply waveforms

The load causes the capacitor to discharge between half cycles. If the load current stays constant, as it will for small ripple, then

$$I = C\frac{dV}{dt}$$

The frequency of the full wave signal is double the input frequency. This makes sense. A full wave output has twice as many cycles as the sine wave input has. The full wave rectifier inverts each negative half cycle, so that we get double the number of positive half cycles. The effect is to double the frequency [18].

Therefore, the output frequency of the full wave rectifier is:

$f_{out} = 2f_{in}$

(i.e. twice the input frequency) [14, 18]

This implies that,

$$dt = \frac{1}{2f_{in}} = \frac{1}{(2*50)} = 0.01s$$

This is on the safe side, as the capacitor begins charging up in less than half a cycle.

The maximum current that can be drawn by the main circuit is determined by the voltage regulator following the filtering capacitor, the 7805.

The standard 7800 series can produce output current in excess of 1A when used with adequate heat sink [9]. Therefore, it can supply a maximum of 1A. This current will be drawn from the supply. Thus I_{load} = 1A (maximum). The value of C can then be calculated from

$$C = \frac{Idt}{dv}$$

But generally dv, which is the ripple voltage, is chosen to be 25% of V_p, where V_p is the peak voltage.

Therefore, $V_p = V_{rms}\sqrt{2}$

Where V_{rms} =15V, since the transformer of 220V/15V was used.

⇨ $V_p = 15 * \sqrt{2} = 21.21V$

For bridge rectifier $V_{P(out)} = V_{P(in)} - 1.4V$, since 0.7V dropped across a diode whenever it conducts. And it is only two diodes that will conduct at a time [18].

Therefore, $V_{P(out)} = 15 * \sqrt{2} - 1.4 = 19.81V$

⇨ $dv = (\frac{25}{100}) * 19.81 = 4.95V$

Therefore, $C = \frac{(1 * 0.01)}{4.95} = 2.0202 * 10^{-3}F$

$= 2,020\mu F$

So, the commercial value of 3,300μF, 25V was used in order to reduce the ripple to the nearest minimum. Then, the expected ripple voltage using this value of capacitor is

$$dv = \frac{(1 * 0.01)}{3,300 * 10^{-6}} = 3.03mV$$

This means that the output waveform goes from a peak value of 19.81V to $(19.81-3.03*10^{-6})$ =19.81V. It may be noted that the input voltage to the IC regulator must be at least 2V above the output voltage. This is required in order to maintain regulation [9].

Therefore, the peak value of 19.81V to 19.81V is acceptable since the output voltage is 5V. The ripple is neglected by the 7805 to a negligible value.

The average voltage going to 7805 is calculated by

$V_P - 0.5dv = 19.81-(0.5*3.03*10^{-6}) = 19.81V$

The output from the 7805 is 5V, at maximum current output of 1A. A heat sink is necessary and was screwed on to its back. The output remains constant in spite of input voltage variation.

The output capacitor 0.1μF, connected across the output acts as line filter to improve the transient response [8, 9, 10, 14, 18].

For power indication, a light emitting diode (LED1) is connected from the positive supply line immediately after the capacitor to ground through a resistor. The resistor value is determined by the current carrying capacity of the diode. A typical red LED will drop 1.7V cathode to anode when forward biased (positive anode-to-cathode voltage) and will illuminate with 10 to 20mA flowing through it [13]. Since the red LED is used as an indicator, then the required limiting resistor can be calculated as:

$$19.81 = V_d + I_d R = 1.7 + 10mA * R$$

$$\text{Therefore, } R = \frac{19.81}{10 * 10^{-3} A} = 1.981 k\Omega$$

The commercial value of 2.2kΩ was used in the design.

The diode and resistor served as a path to ground which the smoothing capacitor can discharge after the supply has been turned off. This prevents high voltages that might damage other parts of the circuit.

3.2 Design of Time-Select Switching Unit

This unit made provision for the selection of timing suitable for a particular School. This is done by pressing the switch that corresponds to the School schedule on the time-table.

It is considered that a School has a total of eight (8) periods with a breakfast after the fourth period.

3.2.1 Calculation of Pull-up Resistors

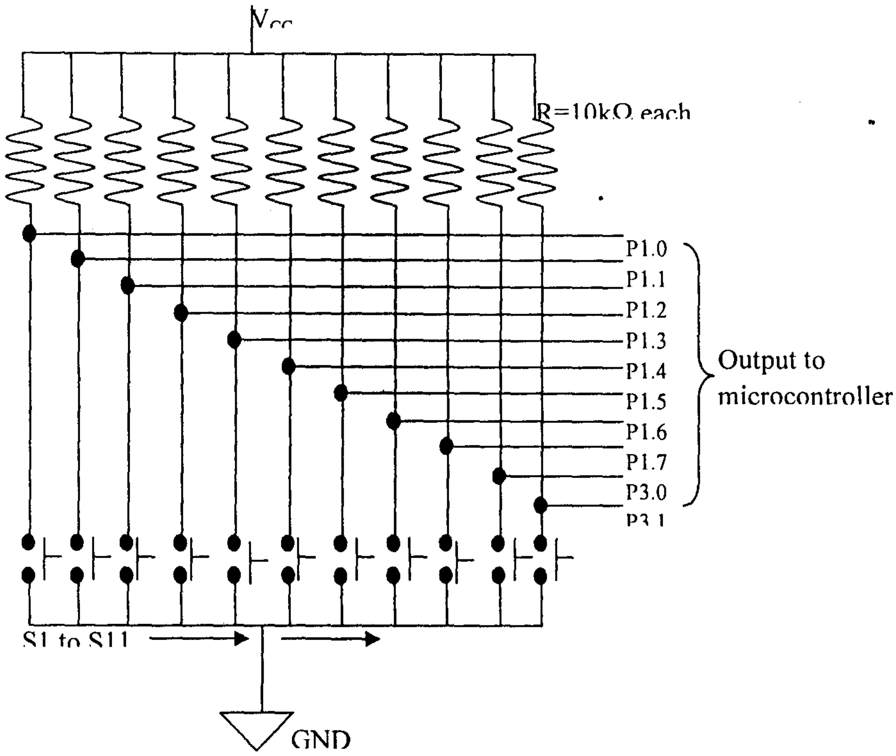


Fig. 3.4: Circuit diagram of the time-select switching

Fig.3.4 shows the circuit diagram of the time-select switching unit. The circuit consists of eleven (11) push-to-on switches, S1 through S11. Each switch is connected from the pins of microcontroller to the ground. Every microcontroller has ability to sink or source current. The type of microcontroller used in this design is AT89S51.

From the datasheet [22] of AT89S51, port1, 2 and 3 can sink current of about 1.6mA. Therefore, by taking the sinking current to be 0.5mA, the pull-up resistors can be calculated.

From the fig.3.4, $V_{cc} = IR$,

Where $V_{cc} = +5V$, $I = 1.5mA$, R = pull-up resistor.

Therefore, $R = \frac{Vcc}{I} = \frac{5V}{0.5mA} = 10k\Omega$

3.2.2 Description

The switches were connected in such away that, they were held HIGH with the 10kΩ pull-up resistors. All switches are normally opened switch which has the contact by pressing the button and loose contact by releasing the button. Each switch from S1 to S10 represents a single schedule, which give a total of ten (10) different timing schedules. A single schedule has a total of eight (8) periods with a breakfast after the fourth period. The eleventh switch, S11 provides room for any emergency that arises which will leads to bell ringing, thus called an emergency switch. This emergency switch is common for every schedule selected and active at any point in time during the School hours.

The Table 3.1 shows ten (10) different possible timing schedules available for this design.

Table3.1: Ten (10) different schedules

S/NO.	Schedule	Switch Symbol	Duration Per Period (In minutes)	Duration of the Break (In minutes)
1.	1	S1	45	40
2.	2	S2	45	30
3.	3	S3	45	20
4.	4	S4	40	40
5.	5	S5	40	30
6.	6	S6	40	20
7.	7	S7	35	40
8.	8	S8	35	30
9.	9	S9	35	20
10.	10	S10	30	20

3.2.3 Principle of Operation

The pins that were connected to the switches are held HIGH by the pull-up resistors. The I/O ports of the 8051 microcontroller can be both read and written to (bidirectional), therefore, if any of the switches, after being powered, is pressed to select the schedule, the concerned pin of the microcontroller will be pulled down to ground which serves as the input to the microcontroller. When microcontroller senses a signal from that pin, it will start executing some specific instructions as directed by the software programming. Emergency switch always active at every point in time, once the schedule has been chosen.

3.3 Design of Microcontroller Unit

The major component in this project design is AT89S51 microcontroller which controls, coordinates and directs all the activities and behaviors of this design. Most control application required extensive I/O and need to work with individual bits. The AT89S51 addresses both of these needs by having 32 I/O, bit manipulation and bit checking.

The input from timing unit to the microcontroller, automatically select the corresponding timing programmed within the microcontroller chip. The output of this goes to the LED indicator and inverter units. Fig.3.5 shows the unit circuit diagram. 1µF is connected from Vcc to the reset pin of microcontroller.

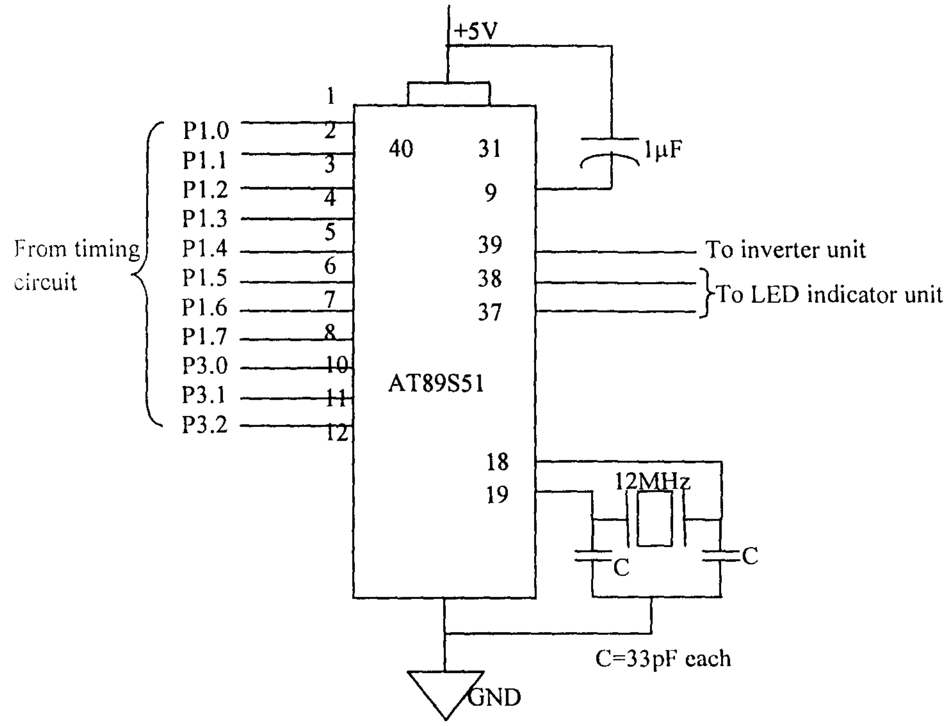


Fig. 3.5: Circuit diagram of Microcontroller Unit

3.3.1 Features of AT89S51

• Compatible with MCS-51™ Products

• 4K Bytes of In-System Reprogrammable Flash Memory

• Endurance: 1,000 Write/Erase Cycles

• Fully Static Operation: 0 Hz to 24 MHz

• Three-level Program Memory Lock

• 128 x 8-bit Internal RAM

• 32 Programmable I/O Lines

• Two 16-bit Timer/Counters

• Six Interrupt Sources

• Programmable Serial Channel

• Low-power Idle and Power-down Modes

3.3.2 Oscillator Characteristics

XTAL1 and XTAL2 are the input and output, respectively, of an inverting amplifier which can be configured for use as an on-chip oscillator, as shown in Fig. 3.5. Either a quartz crystal or ceramic resonator may be used. In this design, a quartz crystal was used.

From the datasheet of AT89S51 [25], it is noted that

C1, C2 = 30 pF ± 10 pF for Crystals

= 40 pF ± 10 pF for Ceramic Resonators

Therefore, since crystal was used, 33pF was chosen for both C1 and C2 as shown in fig. 3.5.

3.4 Design of LED Indicators Unit

The circuit diagram of this unit is as shown in fig. 3.6. The limiting resistance can be calculated as follows:

From [13], the voltage across the LED is 1.7V

From the datasheet of AT89S51 [22], the sinking current of port 0 is 3.2mA

For LED to glow, 1.7V must drop across its terminal

Therefore, $V_{CC} = V_{LED} + IR$

Where V_{CC}=+5V

R=limiting resistance for an LED,

$$R = \frac{(V_{CC} - V_{LED})}{I} = \frac{(5-1.7)}{3.2 * 10^{-3}}$$

=1.03kΩ

Therefore, the commercial value of 1kΩ was used in the design.

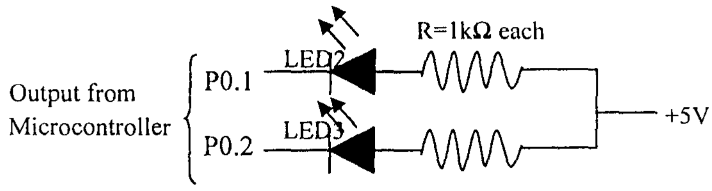


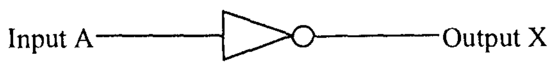
Fig. 3.6 LED Indicator Circuit Diagram

LED1 which has green color glows immediately after a schedule has been selected, indicating that the School bell is active. It remains ON throughout the School periods.

LED2 which has red background oscillating at every second after the last period of the Scho l hour is over. It indicates the end of the School periods.

3.5 Inverter (NOT) Gate

The inverter is used to complement or invert a digital signal. It has a single input and a single output. If a HIGH level (1) comes in, it produces a LOW level (0) output. If a LOW level (0) comes in, it produces a HIGH level (1) output. The symbol and truth table for the inverter gate are shown in fig. 3.6. (Note: the circle is the part of the symbol that indicates inversion.)



(a) Symbol

Table 3.2 Truth table of Inverter (NOT) Gate

Input A	Output X
0	1
1	0

(b) Truth table

Fig. 3.7 Inverter symbol and truth table

3.5.1 Operation of the Inverter

The operation of the inverter is very simple and can be illustrated further by studying the timing diagram of fig. 3.7. The timing diagram graphically shows us the operation of the inverter. When the input is HIGH, the output is LOW, and when the input is LOW, the output is HIGH. The output waveform is, therefore, the exact complement of the input.

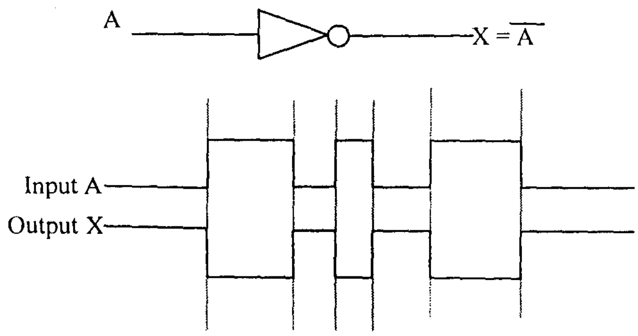


Fig. 3.8 Timing analysis of an Inverter Gate (waveform sketch)

The Boolean equation for an inverter is written as

$X = \overline{A}$ (X = NOT A). The bar over the A is an inversion bar, used to signify the complement. The inverter is some times referred to as the NOT gate. The 7404 hex inverter IC was the IC gate used in this design.

3.5.2 The 7404 hex inverter

A single TTL integrated circuit (IC) package such as the 7404 has six complete logic circuits fabricated into a single silicon chip. The 7404 has 14 metallic pins connected to the outside of a plastic case containing the silicon chip.

The pin configuration of the 7404 is shown in fig. 3.8. The power supply connections to the IC are made to pin 14 (+5V) and pin7 (ground), which supplies power to all six logic circuits. In the case of the 7404, the logic circuits are called inverters.

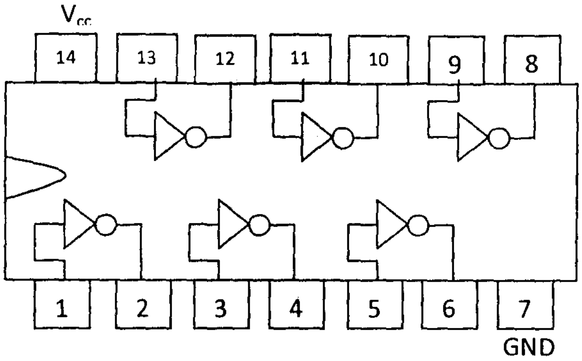


Fig. 3.9 A 7404 hex inverter pin configuration

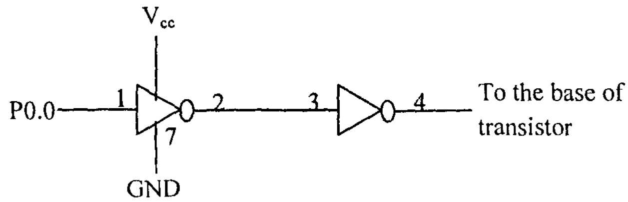


Fig. 3.10 Circuit diagram of Inverter Unit

From fig. 3.10, the output of microcontroller goes to pin1 of 7404 which is inverted and came out of pin2. The output of pin2 then goes to pin3 which is also inverted and came out of pin4, as the input to the base of switching transistor. This means that, whatever comes out of the P0.0 of microcontroller is amplified through the two inverters looped together and served as the input to the switching transistor. The inverter was used, since AT89S51 does not source the sufficient current to trigger the base of the transistor. For example, if microcontroller brings out logic HIGH (1), it is that HIGH (1) after amplified that entered the base of transistor.

3.6 Design of Relay Driver Unit

The transitions between 0 and 1 digit levels are caused by switching from one voltage level to another (usually 0V to +5V). One way that switching is accomplished is to make and break a connection between two electrical conductors by way of a manual switch or an electromechanical relay. Another way to switch digital levels is by use of semiconductor devices such as diodes and transistors [13]. Thus, this is the unit that controls the ON and OFF of the School bell and it comprises of switching transistor and relay.

3.6.1 Transistor as a Switch

In an electronic circuit, the input signal (1 or 0) is usually applied to the base of the transistor, which causes the collector-emitter junction to become a short or an open circuit. The rules of transistor switching are as follows: [13]

1. In an NPN transistor, applying a positive voltage from base to emitter causes the collector-to-emitter junction to short (this is called "turning the transistor ON"). Applying a negative voltage or 0V from base to emitter causes the collector-to-emitter junction to open (this is called "turning the transistor OFF").

2. In a PNP transistor, applying a negative voltage or 0V from base to emitter turns it ON. Applying a positive voltage from base to emitter turns it OFF.

When a transistor is used as a switch it must be either OFF or fully ON. In the fully ON state the voltage V_{CE} across the transistor is almost zero and the transistor is said to be saturated because it can not pass any more collector current I_C. The output device switched by the transistor is usually called the 'load'.

Refer to the fig. 3.11. In the case of a transistor, there is a time delay between the leading edge of the input voltage pulse and the time that the collector current takes to reach 90% of its maximum value. This is known as the turn-on time. The time required for the collector current to decrease from $I_{(sat)}$ when input voltage goes negative is called the turn-off time.

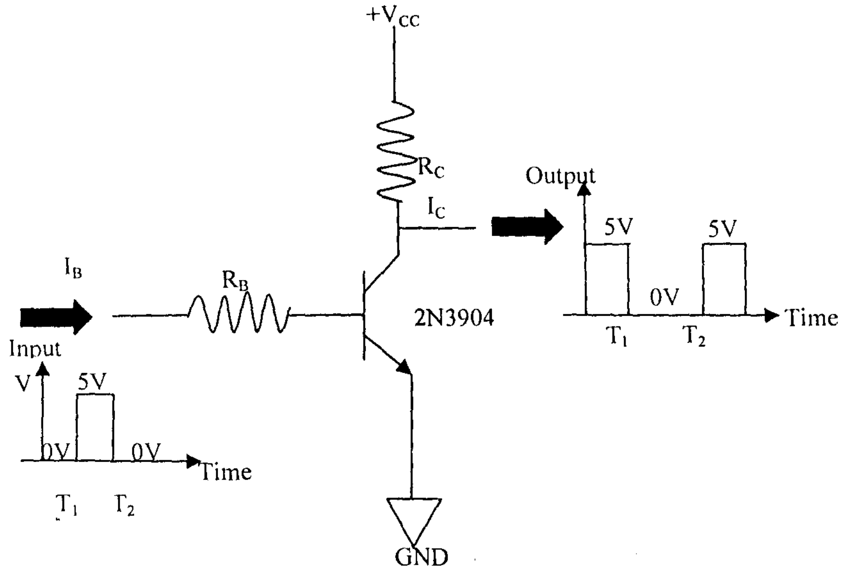


Fig. 3.11 Transistor as a switch

3.6.2 Calculation of Base Resistance, R_B

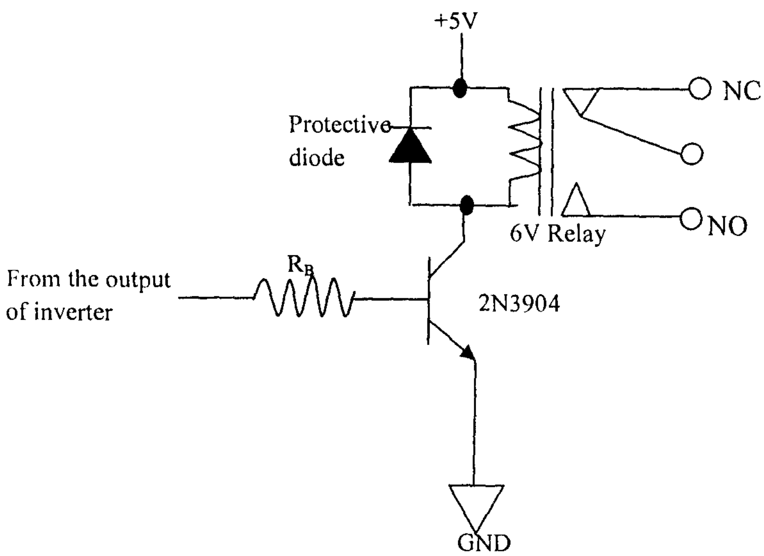


Fig. 3.12 Circuit Diagram of Relay Driver Unit

From fig. 3.12, the load resistance which is the collector resistance is the resistance of the relay coil. The 6V relay used has the coil resistance of 100Ω. Therefore, R_C=100Ω. The NPN transistor used is 2N3904. Thus, from datasheet of 2N3904 [23],

$I_{C(max)}$= 200mA, $h_{FE(max.)}$ = 300.

diode is connected 'backwards' across the load, in this case a relay coil. It is known from the basic circuit courses that the current through a coil cannot change instantaneously, and in fact, the more quickly it changes, the greater the induced voltage across the coil as defined by

$V_L = L(\frac{di_L}{dt})$.

In this case, the rapidly changing current through the coil will develop a large volta[illegible]ss the coil with the polarity shown, which will appear directly across the output of the transistor. The changes are likely that its magnitude will exceed the maximum ratings of the transistor, and the semiconductor device will be permanently damaged. The voltage across the coil will not remain at its highest switching level but will oscillate as shown until its level drops to zero as the system settles down.

This destructive action can be subdued by placing a diode across the coil as shown. During the "ON" state of the transistor, the diode is back-biased; it sets like an open circuit and does not affect a thing. However, when the transistor turns OFF, the voltage across the coil will reverse and forward-bias the diode, place the diode in its "ON" state. The current through the inductor established during the "ON" state of the transistor can then continue to flow through the diode eliminating the severe change in current level [14].

3.7 Output of the Logic Circuit

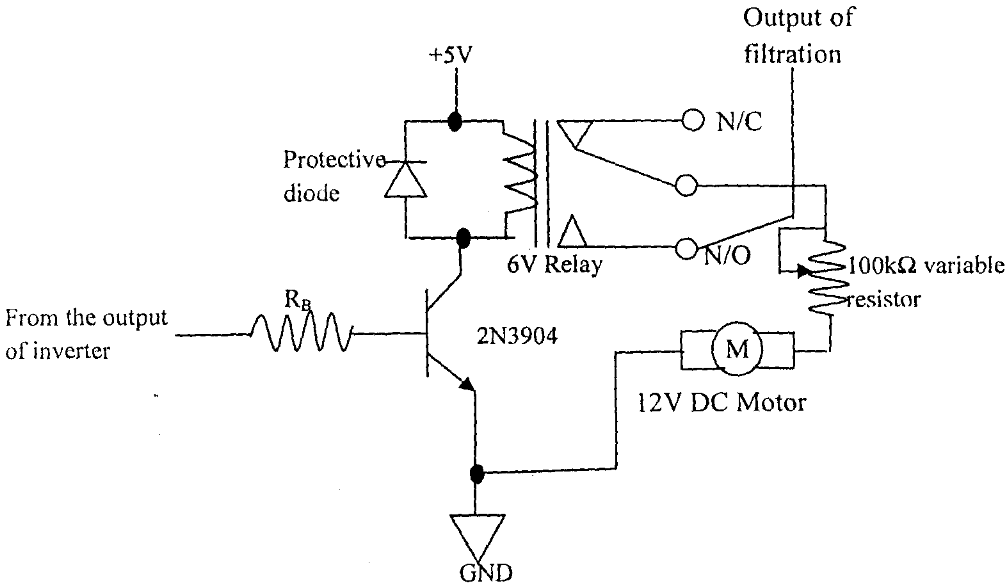


Fig. 3.14: Circuit Diagram of Relay and Motor

The circuit in fig. 3.13 uses a relay to isolate an electric motor from the logic devices. Notice that the logic circuit and dc motor have separate power supplies. When the output of inverter goes HIGH, the transistor is turned on and the NO contacts of the relay snap closed. The dc motor operates. The dc motor provides a rotary motion, which drives the mechanical devices that result in bell ringing. The bell keeps on ringing for long as the dc motor rotates. When the output of the inverter goes LOW, the transistor stops conducting and the relay contacts spring back to their NC position. This turns off the motor, thereby stopping the bell from ringing. The 560kΩ variable resistor connected in series with the motor is use to regulate the rpm of the motor, thereby setting the ringing frequency of the bell.

3.8 Complete Circuit Diagram

The circuit in fig. 3.14 shows the complete circuit diagram of the design.

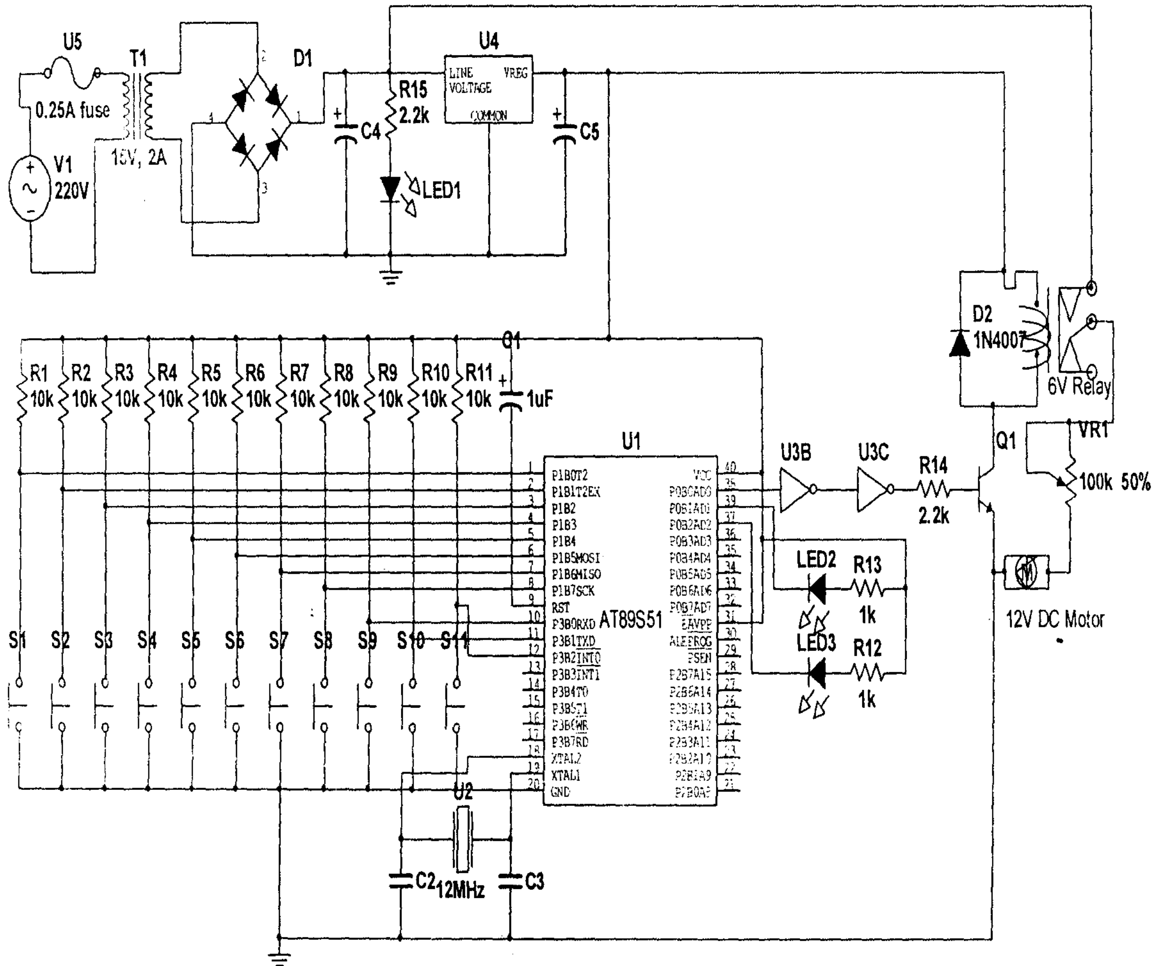


Fig.3.15 Complete Circuit Diagram of an Automatic School Bell

3.9 Construction

The complete circuit was constructed on a 20*10cm Vero board. The flow of the logic signal was noted and the different sections were laid out accordingly. The power circuit was constructed on a separate Vero board and the output was taken through wires to the required points in the main board. The switches to the selection of different schedules were also constructed on a separate board and wires were drawn to the main board. This was done

iii. Microcontroller Unit

(a.) One AT89S51 microcontroller

(b.) One 12MHz crystal

(c.) Two 33pF capacitor

(d.) One 1μF capacitor

iv. LED Indicator Unit

(a.) Two LED's

(b.) Two 1kΩ resistor

v. Inverter Unit

(a.) One 7404 hex inverter

vi. Relay Driver Unit

(a.) One 2.2kΩ resistor

(b.) One 2N3904 NPN transistor

(c.) One IN4007 diode

(d.) One 6V relay

vii. Output

(a.) One 12V dc motor

(b.) One 560kΩ variable resistor

CHAPTER FOUR

TESTS, RESULTS AND DISCUSSION

4.1 Testing

An AT89S51 microcontroller is a programmable IC, which needs to be programmed to suit the design. The source code was first compiled on the notepad and then test ran on Edsim51 Simulator. Proper concentration was given to the code during compilation in order to avoid any logic errors. The hex file was then generated and transferred to the chip with the aid of a programmer.

All the ICs were tested separately on a bread board to make sure they work properly. The whole circuit was also tested on the bread board to make sure it was design correctly. During construction, each section was tested as it was built to make sure the connections were done correctly before going onto the next section. This was done by applying the correct logic signals to the ICs and observing the output.

After construction, the bell was tested for every schedule and the time was monitored with a stop-watch to know when the bell is ringing. The results obtained were tabulated in the next section.

4.2 Results

After testing the bell, the following tabulated results in Table 4.1 were obtained.

Table 4.1: Results obtained from testing

S/NO.	DURATION PER PERIOD		DRIFT PER PERIOD (In seconds)	TOTAL DRIFT AFTER THE LAST PERIOD (8*drift) (In seconds)
	SELECTED (In minutes)	MEASURED		
1.	45	45min 2sec	2	16
2.	40	40min 1sec	1	8
3.	35	35min 0sec	0	0
4.	30	30min 0sec	0	0

Total drift=8*drift per period

Since every schedule has maximum number of eight (8) periods.

4.3 Discussion of the Results

By looking at the results obtained in section 4.2, various deductions can be made. The results are explained as follows:

The drift in 45min is more than that of 40min by 1sec. While in 35min and 30min, there was no drift. This therefore, means that the higher the time schedule, the more the drift in it. This might have due to accumulation of the execution of some microsecond's instructions that were not taken into consideration during the programming.

By looking into the table of the results, it was discovered that at the end of the School periods, 45min periods has increased by at least 16seconds while that of 40min has increase by 8seconds. This implies that the seconds' increment can be negligible since an individual timer clock varies. Thus, this is accurate enough for most applications

CHAPTER FIVE

CONCLUSION

5.1 Conclusion

The basic design of the Automatic School Bell mainly for Primary and Secondary Schools in this project remains the same though extra functions can be included. This will ring School Bell at pre-scheduled times of period on each day. There are different times per period, from one School to the other. The project provides chances of selecting the suitable time schedule for every School, by momentarily pressed one of the push-to-on switches. This signal the microcontroller to carried out the specific task thereby ringing the bell at a regular interval.

Therefore, from the results obtained, it can be concluded that the aim of this project work has been practically and theoretically achieved.

5.2 Possible Improvement

There are a lot of other things that can be included in the project to increase its functionality, performance and dynamism. Some of these are given below:

i. Inclusion of a digital clock, so as to read and display time of the day.

ii. Inclusion of a rechargeable battery source for back-up in case the power fails, so as to maintain the School periods of the day.

iii. Interfacing a keypad with microcontroller based system, so as to provides room for entry of time per period as desired by every School.

iv. An AC motor can be used instead of DC motor, so as to use a very big Bell that can ring and cover a wider area across the vicinity of the School.

5.3 Recommendation

In respect to the features included in this work, it could be useful for the following recommended areas below:

i. It could be used mainly in Primary and Secondary Schools where bell play a significant role.

ii. It could be used in Industries where a specific work is to be carried out at a regular interval.

iii. It can be used in a seminar where lectures are delivered at a regular interval

iv. It can also be used for other applications where you want a sound to play at preset times.

v. Finally, it can be used in some other businesses where the bell timer plays a critical role in running the day.

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APPENDIX A: USER'S MANUAL

AUTOMATIC SCHOOL BELL

A. Power Supply

Plug in the power cable into ac main. Then turn ON the toggle switch to power the device. The power indicator (Red LED) glows, meaning that the device is now powered.

B. Selection of the schedule

It is considered a School has a total number of eight periods with a breakfast after the fourth period. There is ten (10) different schedules. The duration per period differs from one schedule to the other, so also the duration for breakfast.

To ring this Automatic School Bell to start the first period, the time-keeper needs to choose the suitable schedule by momentarily press the corresponding switch. Thereafter, the Bell sound every time of the period to indicates the end of consecutive periods, except immediately after the fourth period where it sounds after the breakfast time to indicate that breakfast is over. When the last period is over, LED indicator labeled 'END' glows by oscillation to indicate that the Bell circuit should now be switched off manually.

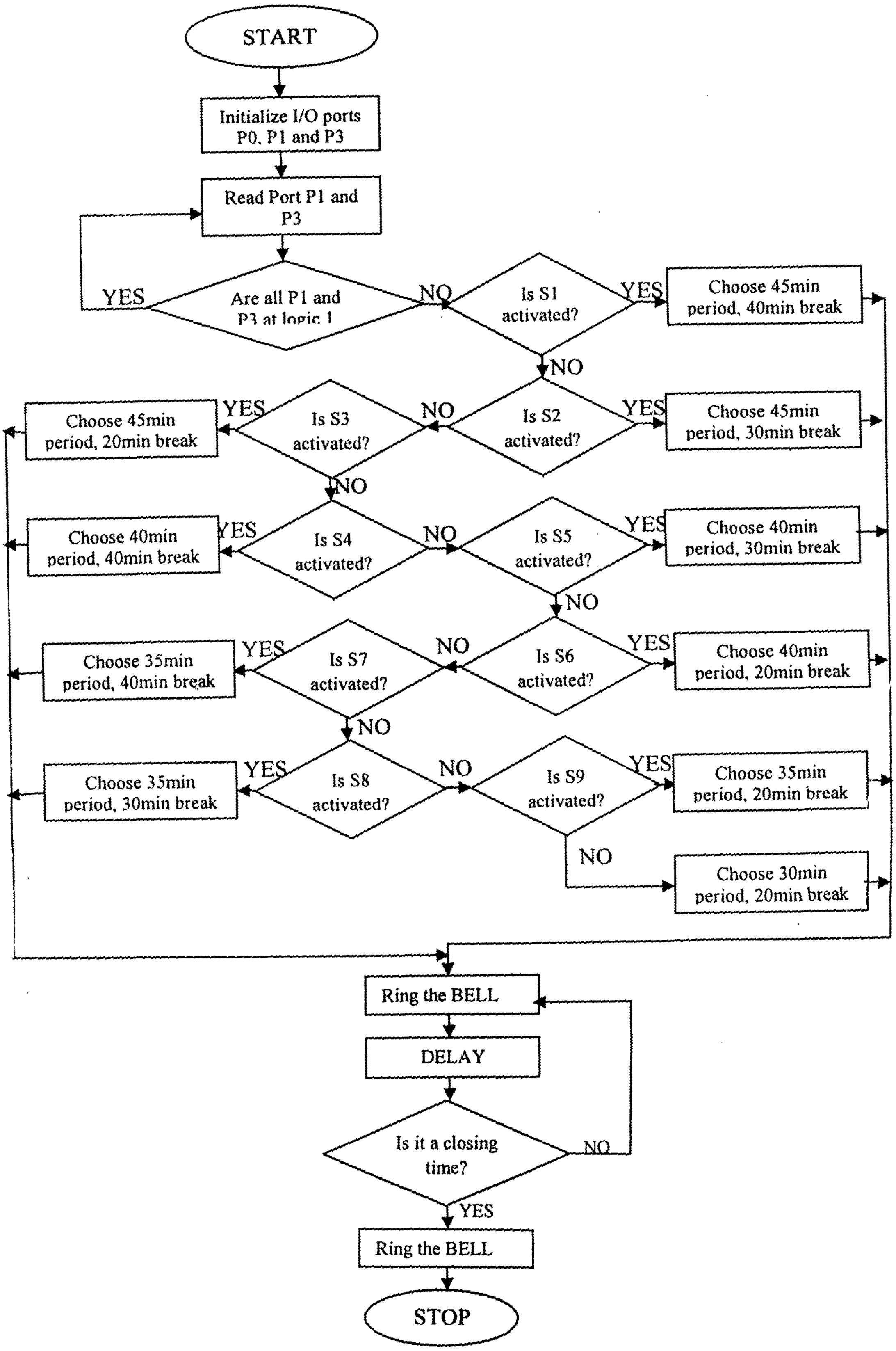
Example, if switch labeled S1 is pressed, a 45minutes per period and 30minutes break is automatically selected by the microcontroller. The table below explained better.

Table of ten (10) schedules:

S/NO.	SWITCH LABEL		DESCRIPTION
1.	S1	45/40	45 minutes per period and 40 minutes break
2.	S2	45/30	45 minutes per period and 30 minutes break
3.	S3	45/20	45 minutes per period and 20 minutes break
4.	S4	40/40	40 minutes per period and 40 minutes break
5.	S5	40/30	40 minutes per period and 30 minutes break
6.	S6	40/20	40 minutes per period and 20 minutes break
7.	S7	35/40	35 minutes per period and 40 minutes break
8.	S8	35/30	35 minutes per period and 30 minutes break
9.	S9	35/20	35 minutes per period and 20 minutes break
10.	S10	30/20	30 minutes per period and 20 minutes break

NOTE: The switch S11 labeled E, is the EMERGENCY switch. It rings the Bell for 15 seconds whenever it is pressed

Front view of the design


START
Initialize I/O ports P0, P1 and P3
Read Port P1 and P3
Are all P1 and P3 at logic 1
YES
NO
Is S1 activated?
YES
Choose 45min period, 40min break
NO
Is S2 activated?
YES
Choose 45min period, 30min break
NO
Is S3 activated?
YES
Choose 45min period, 20min break
NO
Is S4 activated?
YES
Choose 40min period, 40min break
NO
Is S5 activated?
YES
Choose 40min period, 30min break
NO
Is S6 activated?
YES
Choose 40min period, 20min break
NO
Is S7 activated?
YES
Choose 35min period, 40min break
NO
Is S8 activated?
YES
Choose 35min period, 30min break
NO
Is S9 activated?
YES
Choose 35min period, 20min break
NO
Choose 30min period, 20min break
Ring the BELL
DELAY
Is it a closing time?
NO
YES
Ring the BELL
STOP

APPENDIX C: SOURCE CODE

```
ORG 0000H
CLR A
MOV P0, #0FEH
MOV P3, #0FFH
MOV P1, #0FFH
LCALL one_sec_sub
test_switch_1:
        JB P1.0, test_switch_2
        SJMP switch_1
test_switch_2:
        JB P1.1, test_switch_3
        LJMP switch_2
test_switch_3:
        JB P1.2, test_switch_4
        LJMP switch_3
test_switch_4:
        JB P1.3, test_switch_5
        LJMP switch_4
test_switch_5:
        JB P1.4, test_switch_6
        LJMP switch_5
test_switch_6:
        JB P1.5, test_switch_7
        LJMP switch_6
test_switch_7:
        JB P1.6, test_switch_8
        LJMP switch_7
test_switch_8:
        JB P1.7, test_switch_9
END
```