Design and Construction of a Light Dependent Automatic-Off Timer for CD Players

BY

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DEDICATION

I dedicate this work to my parents Late Alh. Aliyu Rainbow Alabi and Mrs. (Hajia) Aliyu Barikisu Avosuahi

ATTESTATION/DECLARATION

I **ALIYU KABIRU ADEIZA** 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 copyright to the Federal University of Technology, Minna.

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ABSTRACT

This project was undertaken to design and construct a device that would be of use to persons who are in habit of falling asleep while listening to music. The scope of work ranges from conceptualization of the idea and theories behind the operation of the device to the stage of packaging the design.

The unit provides automatic disconnection of the CD player from the AC mains supply upon the expiration of a preset time delay period. The system works for detecting a transition from light to darkness in a room which triggers the device into a time-out mode. During the time-delay period, the CD player is connected to the mains supply. Disconnection occurs after the pre-set time delay period elapses.

Test carried out produce efficient result which meets the main objective of the project. In recommendation I would suggest that the timing can be increased by modifying the software.

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CHAPTER ONE

INTRODUCTION

A switch can simply be defined as a device operated to turn electric current on device operated to turn electric current on or off. Switches are therefore very important devices in electrical electronics circuit designs and are hence widely used components serving as control devices in modern electrical systems and circuits. Switches can also be defined as device by which a circuit parameter or signal such as electrical current can be either linked to or cut off from another part of a circuit manually or automatically.

This project is simply the design (both theoretical and practical) of a system or device that would operate as a switch that would turn off automatically alternating current (AC) power supply to a CD player after a pre-set time delay. A key feature of this device is that its operation is light dependent that is the device is activated only when it is powered on in the presence of ambient light or in a sufficiently dark environment making it a light dependent automatic-off timer for CD players.

The light dependent automatic-off timer uses a light dependent resistor (LDR) as its light sensor. It has the following key components:

- A 555 timer integrated circuit (IC) based Schmitt trigger with the light sensor (LDR) at its input.
- Microcontroller (89C2051) which is an 8-bit microcontroller with 2k byte of reprogrammable flash memory.
- A normal closed (N/C) relay at the output interface of the device.
- Light emitting diode (LED) visual display. The above mentioned components give the device its peculiar function. The presence of the LDR makes the device light sensitive and when the room is sufficiently dark, the sensor will have high impedance which will turn pass a high voltage into the input of the Schmitt

trigger. The Schmitt trigger being a logic inverter will pass a low signal to reset the microcontroller. As long as light is detected, the microcontroller is reset. When light fails, the 555 timer output goes low and the microcontroller starts executing the system routine stored on its on-chip FLASH memory. The microcontroller keeps track of time by counting how many microseconds have elapsed since coming out of reset mode. The system runs off a 12MHz source. After every 60 seconds, a variable minute is decremented. When minute is zero, the load that was initially on is switched off after 60 seconds.

1.1 OBJECTIVES

The project involves the design and construction of an packaged circuitry that will eliminate the need that will manually turn-off AC power supply to electronic appliances. Hence, the major objective of this project is to effectively design and fabricate an electronic device that will be capable of switching off AC power supply automatically from electronic appliances connected to its output interface at night (in dark environment). This device therefore makes it possible for persons to use electronic appliances such as the television set and CD players as they await sleep leisurely late at night.

Furthermore, the devoice finds use not only in homes but as a precautionary and protected interface in industries and offices; serving as a switch to turn-off when night falls, AC power supply from electronic appliances left o carelessly or negligibly by workers during the day.

1.2 METHODOLOGY

The logical sequence of steps followed in the design and construction of this device is outlined as follows:

1.2.1 CONCEPTUALIZATION

This is the first stage off and marked the beginning of the project work. Here at this stage, the concept of idea underlying the whole project work. Researches particularly aimed at finding out component parts and individual functional blocks that would make up the entire device or system were also carried out.

1.2.2 DESIGN

In the design stage, there would be a detailed work on the idea that has been chosen in the first stage. An electrical circuit that would perform the desired function and purpose of the project in mind must be developed and drawn. Every discrete electronics component that would be used must be defined as well as their circuit parameter values. At the end of this stage, the circuit diagram exist showing all discrete components used in the design and a logical assembly of functional blocks that would make seamless operation of the device possible.

1.2.3 PURCHASE OF DISCRETE ELECTRONIC COMPONENTS

This stage in the methodology sequence is as important as any other as the proper functioning of finished products depends on the accurate purchase of the component detailed in the circuit diagram. Components to be purchase include resistors, capacitors, diode, step-down transformer, relay, transistor, 555 timer IC, Light Emitting Diode (LED) display and micro controller (89C2051). Some of the components would be purchased in electrical shops while others could be sourced from scraped electronic boards.

1.2.4 FABRICATION

The objective of this stage is simply to develop a hardware duplicate of the electrical circuit diagram. This involves soldering the purchase discrete components into on a Vero board ensuring consistency with the drawn circuit diagram. Soldering of components is done after the circuit is tested on a breadboard and its performance deemed satisfactory.

1.2.5 PACKAGING

What is done on this stage of the methodology is to prepare a compatible casing that will house and protect the delicate soldered circuit hardware. Care must be taken to ensure that the choice of casing will allow for the display of visual electronic components like the light emitting diode (LED) indicator, and seven segment LED display. Hence special slots will be made for LED indicator, the sensor on the external surface of the casing and LED visual display.

1.3 LIMITATIONS AND CONSTRAINTS

Maximum timing delay of 99 minutes. The limitation can be removed by timing the software.

1.4 SCOPE OF WORK

The scope of work for this project work ranges from the point or stage of conceptualization to the final technical report writing of the finished work or project. It involves all the steps outlined earlier in the methodology and spans to the preparation of the written thesis of the project work.

CHAPTER TWO

LITERATURE REVIEW

The light dependent automatic-off timer has its operation based on the availability of Direct Current (DC) power supply just like any other electronic device or appliance. Also, its operation has basic underlying theories and principles, therefore in this chapter two undertake to introduce and explain the fundamental electrical principles and theories behind the operation of the device being designed.

2.1 THEORETICAL BACKGROUND

A good understanding of the build up of all functional sub-units, or individual building blocks that compose the whole system is necessary to grasping the theoretical principles backing the device. Appendix A is a block diagram illustrating the logical flow of signal within the structure of the light dependent automatic-off timer. The diagram also highlights the order of interaction between each functional blocks and sub-units.

2.1.1 DC POWER SUPPLY SUB-UNIT

The Power Holding Company of Nigeria (PHCN) is the national body in Nigeria that is responsible for the generation, transmission and distribution of electrical power to consumers across the country. There are basically two forms in which electrical power can be generated, transmitted and distributed: AC power and DC power.

In Nigeria, electrical power is generated, transmitted and distributed in the AC power form. The production of electrical power as AC power is far more preferable to power production in DC power for the following reasons:

i In power generation, it is possible in practice, to construct large high-speed AC generators of capacities up to 500MW. On the other hjand, DC generators cannot be built on rating higher than 5MW because of commutation trouble. Moreover, since they must operate at low speed, it necessitates large and heavy machines.

ii AC generators are more economical in matter of cost per kWH of electric energy produced as well as in operation.

iii AC voltage can be efficiently used and conveniently raised or lowered for economic transmission and distribution of electric power respectively while DC power has to be generated at comparatively low voltage by units of relatively low power ratings. [1]

Therefore, it follows that the form of electrical power available to consumer is AC power. This makes it necessary for the electronics engineer to provide an electronic circuit capable of converting the input AC power to DC power that is required for the operation of any electrical device.

The process of electrical power conversion from AC to DC power or voltage is called rectification. The rectifier is an electronic circuit that can convert AC voltage to DC voltage [2]. The DC supply unit is therefore an electronic sub-unit that has the capability to step down (transform) the voltage to a safe operation level, rectifying the input AC voltage and filtering out pulsation ion the rectified DC voltage. A step down transformer, bridge rectifier and smoothing capacitor serving as filter are required for this function.

The transformer is a device that operates on the principle of electromagnetic induction to step down or step up voltage level by a fixed ratio [3]. It consist of magnetic core with a specific number of both primary and secondary coil winging (N_1 and N_2 respectively). Transformer couple source couple voltages at its primary coil windings to the secondary by means of the magnetic field acting on both coils; hence, a transformer operates by converting electrical energy to magnetic form and then back to electric form [4].

The ratio of voltage transformation of a transformation in given by N_1/N_2 and the expression that gives the transformed output V_2 from an input voltage level of V_1 is: $V_2 = V_1 \times N_2/N_1$. Therefore, for a step down transformer, the number of primary coil winding must be greater than that of the secondary [4]. The transformer simply operates to permit the sealing of the AC voltage level to the desired level. It connects the AC source to the rectifier.

The rectifier is a circuit composing of diodes configured to convert AC voltage to a pulsating DC voltage. The two basic types are full wave rectifier and half wave rectifier. But for basic electronics application, the full wave rectifier is used in preference. A full wave rectifier offers substantial improvement in efficiency over the half wave rectifier as the later utilizes only half of the energy available in the input Ac waveform [5]. The bridge rectifier is an example of a commonly used full wave rectifier.

It consists of four diodes wired in the above configuration. A diode is an electronic device the only allow for the flow of current in one direction when forward biased by an operating DC voltage. A diode is forward biased when its anode potential is higher than that of the cathode; when this condition is satisfied, the diode will pass electric current through it. The rectification operation of the bridge rectifier is based on the property of diode. During the positive half circle of an input AC voltage, two opposite diodes will conduct while the other two become open circuits as they become reverse biased. Similarly, during the negative half-cycle of the input AC voltage, the reverse of the transformer occurs leaving the first two diodes open while the other two conduct [6]. With this process, the rectification process occurs during both the positive and negative half cycles of the AC waveform.

Filtering the rectified output of the rectifier becomes necessary due to ripples that is, the fluctuation about the mean voltage [6]. To solve this problem, the advantage of the energy-storage properties of the capacitor is employed. The capacitor serves as a low pass filter that preserves the DC components of the rectified voltage while filtering out components at frequencies at or above twice the AC signal frequency [6].

Hence, DC power is a circuit that practical applies rectifier circuits in the conversion of AC power to DC power. It consists of a step down transformer, followed by a bridge rectifier and a filter capacitor followed by a voltage regulator. Fig 2.1 is a circuit diagram of a simple DC power supply.

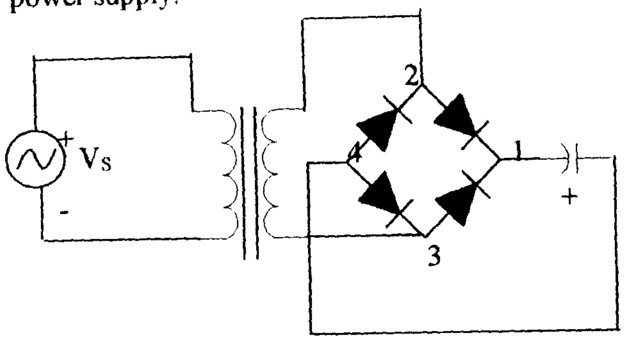

Fig 2.1: Circuit diagram of a simple DC power supply

2.1.2 SENSING STAGE

This stage of the system is responsible for generating the signal (electrical pulse) required to trigger the timer stage or sub-circuit when necessary conditions are satisfied. This stage uses a Schmitt trigger configuration using a 555 timing IC with the light sensor (LDR) at its input.

The LDR or light sensor is connected to the Schmitt trigger's input by a voltage divider circuit involving both the sensor and another resistance value. The voltage divider is an electronic circuit that provides different voltage levels for different sections of a circuit from a common voltage supply. The figure below is a simple voltage divider circuit.

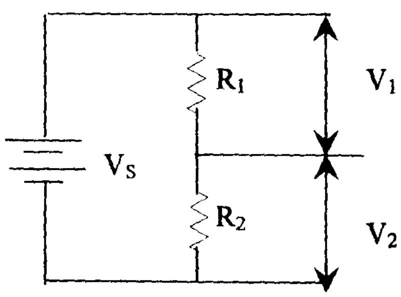

Fig 2.2: Simple Voltage Divider Circuit

Let V_1 be the voltage across R_1 resistor and V_2, the voltage across the second resistor; R_2. This voltage divider circuit divides the supply voltage, V_s into voltage level V_1 and V_2 by the two resistors present. The ratio of division of the supply voltage depends on the value of resistors used in the divider circuit. The value of V_2 is given by the following expression: $V_2 = R_2 / (R_1 + R_2) \times V_s$; and similarly we have $V_1 = R_1 / (R_1 + R_2) \times V_s$; it is important to note also that $V_s = V_1 + V_2$.

The Schmitt trigger is not classified as a flip flop but it does exhibit a type of memory characteristics that makes it useful in certain special conditions that makes it useful; in certain special applications. One of such applications is its use as an inverting buffer [7]. The Schmitt trigger can be configured to function as a standard inverter by using a 555 timer IC with its pins wired as shown by the circuit diagram shown below (Fig 2.3)

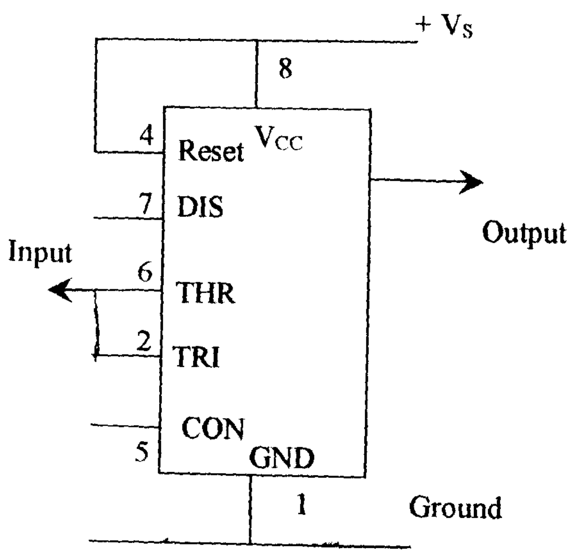

Fig 2.3: 555 timer IC based Schmitt trigger

The input pins (pin 2 and 6) are connected to a common or single input source. Pin 1 is grounded (connected to zero (0V) volts supply lone), while the reset pin (4) and pin 8 are connected together to the positive voltage supply terminal. The output corresponding to the input is taken from pin 3, the output pin of the timer IC.

In this configuration, the 555 timer IC operates as a Schmitt trigger is an inverting buffer or NOT gate because the output logic state (high/low) is the inverse of the input state. Its simple operation is based on the following rules:

- Input low (< ⅓ V_s) makes output high: $+V_s$
- Input high (> ⅔ V_s) makes the output low: 0V [8].

Hence, the Schmitt trigger could serve as a switch, switching between a high and low logic state depending on the voltage level (high or low) that appears at its input.

The buffer circuit input has a very high impedance (about 1mΩ) so it requires only a few μA, but the output can sink up to 200mA. This enables a high impedance signal source such as the LDR to switch a low impedance output transducer or 8-bit microcontroller (AT89C2051).

2.1.3 SYSTEM CONTROLLER UNIT

The timing function of the device is provided by the operation of the 8-bit microcontroller (AT89C2051), which is a low power, high-performance CMOS 8-bit microcomputer with 8kbytes of flash propgrammable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 and 80C52 instruction set and pinout. The on-chip flash allows the programme memory to be reprogrammed in-system or by a conventional nonvolatile 8 bit CPU with flash on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides a highly-flexible and low cost-effective solution to many embedded control application.

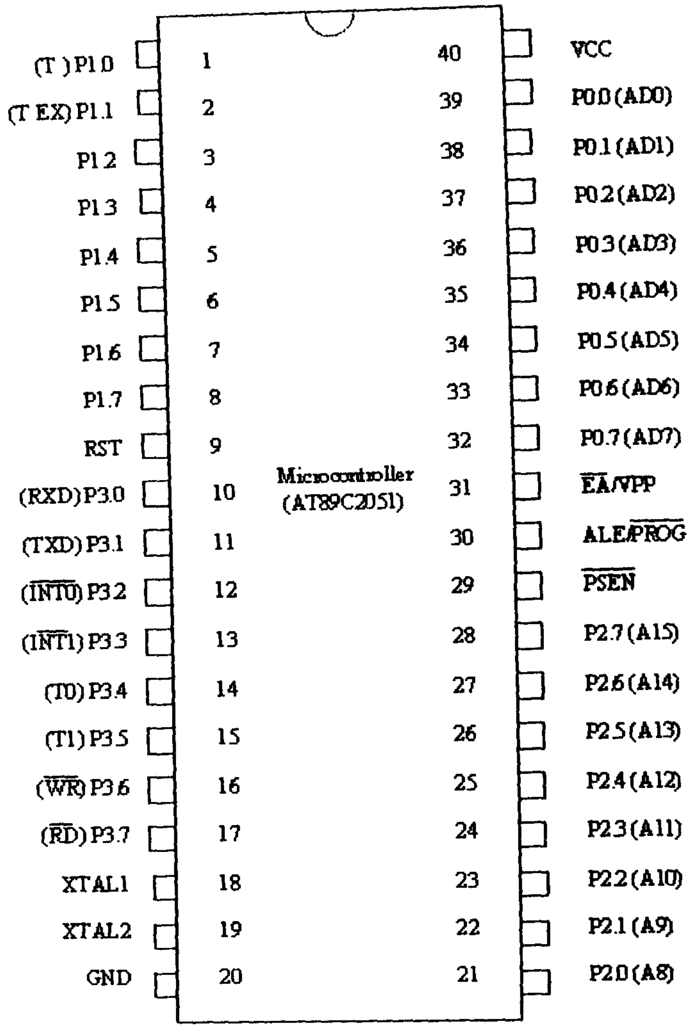

Fig. 2.4: Pin Configuration of AT89C2051

The AT89C2051 provides the following standard features: 8k byte of flash, 256 byte of RAM, 32 I/O lines, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full-duplex serial port, on a chip oscillator, and clock circuitry. In addition, the AT89C2051 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The idle mode stops the CPU while allowing the RAM, the timer/counters, serial port, and interrupt system to continue functioning. The power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next hardware reset.

Pin description

Vcc

Supply voltage

GND

Ground

Port O

Port O is an 8-bit open drain bi-directional I/O port. As an output port, each pin can sink eight TTL inputs. When 1s are written to port O pins, the pins can be used as high-impedance inputs. Port O can also be configured to be the multiplexed low-order address/data bus during accesses to external program and data memory. In this mode, Po has internal pull ups.

Port O also receives the code bytes during flash programming and outputs the code bytes during program verification. External pull-ups are required during program verification.

Port 1

Port 1 is an 8-bit bi-directional I/O port with internal pull-ups. The port 1 output buffers can sink/source four TTL inputs. When 1s are written to port 1 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, port 1 pins that are externally being pulled low will source current (lic) because of the internal pull-ups.

In addition, P1.0 and P1.1 can be configured to be timer/.counter 2 external count input (P1.0/T2) and the timer/counter trigger input (P1.1/T2 EX), respectively, as shown in the following table. Port 1 also receives the low order address bytes during flash programming and verification.

Port Pin	Alternate Function
P1.0	T_2 (external count input to timer/counter) cloul-out
P1.1	T_2EX (Timere/counter 2 capture/reload trigger and direction control)

Table 2.1 showing port 1 pin alternate function

Port 2

Port 2 is an 8-bit bi-directional I/O port with internal pull-ups. The port 2 output buffers can sink/source four input TTL inputs. When 1s are written to port 2 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, port 2 pins that re externally being pulled low will source current (lic) because of the internal pull-ups. Port 2 counts the high order address byte during fetches from external program memory and during accesses to external data memory they use 16-bit addresses (MOVX @ DPTR). In this application, port 2 uses strong internal pull-ups when emitting 1s. during accesses to external data memory that use 8-bit addresses (MOVX @ R1), port 2 emits the contents of the P2 special function register. Port 2 also receives the high-order address bits and some control signals during flash programming and verification [9].

Port 3

Port 3 is an 8-bit bi-directional I/O port with internal pull-ups. The port 3 output buffers can sink/source four TTL inputs. When 1s are written to port 3 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, port 3 pins that are externally being pulled low will source current (lic) because of the pull-ups. Port 3 also serves the functions of various special features of the AT89C2051 as shown in the le. Port 3 also receives some control signals for flash programming and verification.

Port pin	Alternate Function
Port 3.0	RXD (serial input port)
P3.1	TXD(serial output port)
P3.2	INTO (external interrupt O)
P3.3	INTI (external interrupt 1)
P3.4	TO (timer O external input)
P3.5	TI (timer 1 external input)
P3.6	INR (external data memory write strobe)
P3.7	RD (external data memory read strobe)

Table 2.2 showing port 3 pin alternate function

RST

Reset input: A high on this pin for two machine cycles while the oscillator is running resets the device.

ALE/PROG

Address Latch Enable is an output pulse for latching the low byte of the address during access to external memory. This pin is also the program pulse input (PROG) during flash programming. In normal operation, ALE is emitted at a constant rate of 1/6 the oscillator frequency and may be used for external timing or clocking purposes. Note, however, that one ALE pulse is skipped during each access to external data memory. If desired, ALE port can be disabled by setting bit O of SFR location 8EH. With the bit set, ALE is active only during a MOVX or MOVC instruction otherwise, the pin is weakly pulled high. Setting ALE-disable bit has no effect if the microcontroller is in external execution mode.

PSEH

External Access Enable: EA must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFHnote, however, that if clock bit is programmed, EA will be internally latched on reset. EA should be strapped to V_{CC} for internal program executions. This pin al;so receives the 12-volts programmable voltage (V_{PP}) during flash programming 12-volt is selected.

XAL1

Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

XAL2

Output from the inverting oscillator amplifier [9]

2.1.4 VISUAL DISPLAY UNIT

The unit consists of two transistor digital driver and light emitting diode (LED) based 7-segment display. The transistor operates in the common emitter mode. It is a semiconductor device that has three pins namely the base terminal, the emitter terminal and the collector terminal. It can perform two functions that are fundamental to the design of electronics circuits: amplification and switching.

Put simply, amplification consists of magnifying a signal by transferring energy to it from an external source, whereas a transistor switch is a device for controlling a relatively large current between voltage across two terminals [10]. The BJT (bipolar junction transistor) will be considered here because it was used in the design of the light dependent automatic-off timer.

Bipolar junction transistors are formed by joining three sections of semiconductor materials each with different doping levels. Therefore there are two types of BJTs: PNP and NPN BJTs depending on doping technique employed.

For the BJT to function as an amplifier, the operating (quiescent) point must fall in the active region of the transistor. There are three basic amplifier circuits namely: the common-emitter amplifier, the common-base amplifier and the common collector amplifier. In the common-emitter amplifier circuit, the emitter terminal is common to both the input and the output sections of the amplifier circuit, the emitter terminal is common to both the input and the output sections of the of the amplifier configuration hence the name common-emitter. Fig 2.5 is a circuit diagram of a BJT in common-emitter mode

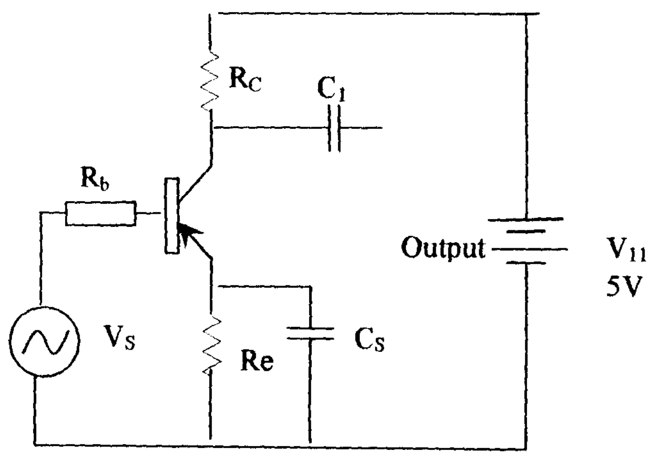

Fig 2.5: Circuit diagram of a BJT in common emitter mode.

V_{CC} is the supply voltage, C_2 is the emitter by pass capacitor and C_1 is the blocking capacitor. R_b, R_C, R_e are the base, collector and emitter terminal reactances respectively. The following are equations used in the DC analysis of the common-emitter amplifier:

$V_{CC} = I_C R_C + V_{ce}$ - - - - - - - - - 2.1

$V_s = I_b R_b + V_{be}$ - - - - - - - - - 2.2

$\beta = I_c/I_b$ - - - - - - - - - 2.3

$I_e = I_b + I_c$ - - - - - - - - 2.4

Where I_c, I_b, I_e are the collector, base and emitter currents and β is the current amplification factor of the transistor.

A seven-segment LED display, less commonly known as a seven-segment indicator is a form of display device that is an alternative to the more complex dot-matrix displays seven-segment displays are commonly used in electronics as a method of displaying decimal numeric feedback on the internal operations of devices.

Seven-segment display, as its name indicates is composed of seven elements. Individually on or off, they can be combined to produce simplified representation of the Hindu-Arabic numerals. Each of the numbers 0, 6, 7 and 9 may be represented by two or more different glphs on seven-segment displays. The seven-segment displays are arranged as a rectangle of two vertical segments on each side with one horizontal segment on the top and bottom. Additionally, the seventh segment bisects the rectangle horizontally.

There are also fourteen-segment displays and sixteen-segment display (for full alphanumeric); however, these have mostly by dot-matrix displays. often the seven segments are arranged in an oblique, or italic, arrangement, which aids readability [11].

Most separate 7-segment displays use an array of light emitting diodes (LEDs), though other types exists using alternative technologies such as cold cathode gas discharge, vacuum fluorescent, incandescent filament, liquid crystal display (LCB), etc.

In a simple LED package, each LEB is typically connected with one terminal to its own pin on the outside of the package and the other LED terminal connected in common with the other LEDs in the device and brought out to a shared pin.

This shared pin will then make up all of the cathodes (negative) OR all of the anodes (positive terminals) of the LEDs in the device; and so will be either a “common cathode” or "common anode" device depending on how it is constructed. Hence a seven-segment plus DP package will only require nine pins to be present and connected [11].

Integrated displays also exist, with single or multiple digits. Some of these integrated displays incorporate their own internal decoder, though most do not – each individual LED is brought out to a connecting pin as described. Multiple-digit LED displays as used in pocket calculators and similar devices used multiplexed displays to reduce the number of IC pins required to control the display. For example, all the anodes of the segments of each digit position would be connected together and to a driver pin, while the cathode of all segments for each digit would be connected. To operate any particular segment of any digit, the controlling integrated circuit would turn on the circuit driver for the selected digit, and the anode drivers for the desired segments; then after a short banking interval the next digit would be selected and new segments lit, in a sequential fashion. In this manner, an eight display with seven-segment and a decimal point would require only 8 cathode drivers and 8 anode drivers, instead of sixty-four drivers and IC pins.

2.1.5 OUTPUT INTERFACE

This stage simply consist of a transistor amplifier operating in the common emitter mode, a relay (normally closed) and a 2-plug socket which serves as the device interface to the outside world. Fig. 2.5 shows the circuit diagram of the transistor.

The relay is simply an electromechanical switch that permits the opening and closing electrical contacts by means of an electromagnetic structure. The working of the relay is as follows: when triggered, an electrical current flow through the relay coil and generates field in the magnetic structure. The resulting force draws the movable part of the relay towards the fixed part causing an electrical contact to be made. One striking advantage of the relay is that a relatively low-level current can be used to control its opening and closing of a circuit that can carry large current [12]. The type of relay used in the foregoing design is the normal closed relay. This relay remains normally closed in an electrical circuit, but when activated, it opens, switching off electric current to another section of the system in which it operates or from any device connected to it.

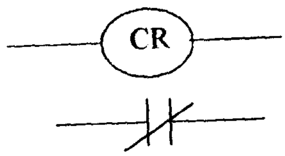

Fig. 2.6: normally closed relay circuit symbol

2.2 HISTORICAL BACKGROUND

A timer is a specialized clock. A timer can be used to control the sequence of an event or process. Timers can be mechanical, electromechanically, digital; or even software, since most computers have clocks. Early timers use typical clockwork mechanisms use a flat beater that spins against air resistance hence they were basically mechanical timers. More accurate mechanism resembles small alarm clocks. The chief advantage of these is that they require no battery and can be stored for long periods of time. The most widely known application is to control explosives [13].

Later on, still in the early 20th century, electromechanical timers emerged and became widely used, replacing its mechanical ancestor. There were two common types: the thermal type, which has a metal finger made of two metals with different rates of thermal expansion (steel and bronze are common). An electric current flows through this finger, and heats it. One side expands less than the other and an electrical contact on the end of the finger moves away from an electrical switch contact, or makes a contact (both type exist).the most common use of the "flasher" units that flash turns signals in automobiles, or sometimes in Christmas lights.

The other type of electromechanical timer (a cam timer) uses a small synchronous AC motor turning a can against a comb of switch contacts. The AC motor is turned at an accurate rate by the alternating current, which power companies carefully regulate. Gears slow this motor down to the desired rate and turn the cam. The most common application of this timer now is in washers, driers and dishwashers. This type of timer often has a friction clutch between the gear train and the cam, so that the cam can be turned to reset the time.

Electromechanical timers survice in these applications since they were often combined with electrical relays to create electromechanical controllers; also mechanical switch contacts are still less expensive than the semiconductor devices needed to control powerful lights, motors and heaters.

Electromechanical timers reached a high state of development in the 1950s and 60s because of their extensive use in aerospace and weapon systems. Programmable electromechanical timers controlled launch sequence events in early rockets and ballistic missiles [13].

However, in modern times, digital timers have become common place since they can achieve higher precision than mechanical timers because they are quartz clocks with special electronics. Integrated circuits have made digital logic so inexpensive that an electronic digital timer is now less expensive than many mechanical and electromechanical timers. Individual timers are implemented as a simple-chip computer system, similar to a watch.

Moreover, in recent times, most timers are now implemented in software, modern controllers use a programmable logic controller rather than a box full of electromechanical parts. The logic is usually designed as if it were relays, using special computer language called ladder logic. In PLCs, timers are usually simulated by the software built into the controller. Each timer is just an entry in a table maintained by the software.

Embedded systems often use a hardware timer to implement a list of software timers. Basically, the hardware timer is set to expire at the timer of the next software timer of a list of software timers. The hardware timers interrupt software handles housekeeping of notifying the rest of the software, finding the next software timer to expire and resetting the hardware timer to the next software timer's expiration [13].

2.3 LIMITATIONS

Maximum timing delay of 99 minutes. The limitation can be removed by modifying the software.

CHAPTER THREE

DESIGN AND IMPLEMENTATION STAGE

The light dependent automatic-off timer of CD players was designed around the under listed sub-units, viz:

- The power supply
- Light sensing unit
- Controller unit
- Load power unit
- Visual display module

3.1 DC POWER SUPPLY UNIT

The supply was contrived as shown below. A 5V regulated DC supply was needed for system operation. A 12V-0-12V step down transformer was used with the 12V-0V winding connected to a full wave bridge rectifier.

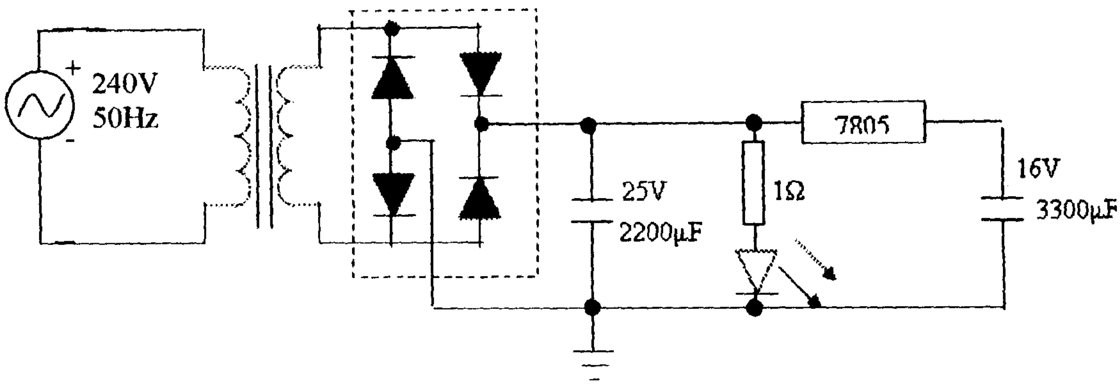

Fig. 3.1: Circuit diagram of the DC power supply unit

The $12V_{AC}$ R.M.S. voltage was connected to the inputs of a full-wave bridge rectifier. The rectified DC voltage was smoothened by a 25V 2200μF capacitance and fed into a 7805 5-volts regulator to produce a ripple-free DC output that power the entire systems.

Design calculations:

$V_{rms} = 12V_{AC}$

$V_{peak} = [(V_{rms} \times \sqrt{2}) - 1.4]V$ - - - - - - 3.1

$= (12 \times \sqrt{2}) - 1.4$

$\approx 15.5V$

V_{DC} = peak voltage across smoothening capacitor

$$V_{DC} = \frac{V_{peak}}{1 + \frac{1}{4FCR_L}}$$ - - - - - 3.2

V_{peak} = peak value of rectified voltage

F = main frequency

R_L = Load connected across rectifies

C = capacitance across the rectifier

R_L is approximately the input resistance of the 7805 regulator and was put at >10kΩ

$Q = CV = It$ - - - - - - - 3.3

$C\Delta V = t\Delta I$ - - - - - - - 3.4

$C_{\Delta V}$ = ripple voltage on the DC

$\Delta I = I_{max} - I_{min}$ drawn by system

To keep ΔV very low, C has to be a high value

A minimum ΔV value of 50mV was stipulated for the supply

$C\Delta V = t\Delta I$

$\Delta I = I_{max} - I_{min}$ of load current

ΔI was measured using a multimeter and found to be 200mA

t = ½F (for a full wave rectifier)

$$C = \frac{t\Delta I}{\Delta V} = \frac{{}^{1}/_{(2 \times 50)}(0.2)}{0.05}$$

$$C = 0.04 \text{ Farads}$$

$$= 40,000\ \mu F$$

This value of capacitance was deemed too light. A 2200μF capacitance was used.

$$V_{DC} = \frac{V_{peak}}{1 + \frac{1}{4FCR_L}}$$

$$V_{DC} = \frac{15.5}{1 + \frac{1}{4 \times 50 \times 2200 \times 10^{-6} \times 10,000}}$$

$$= 15.5V$$

The DC voltage was fed into a 5 volt regulator shown below

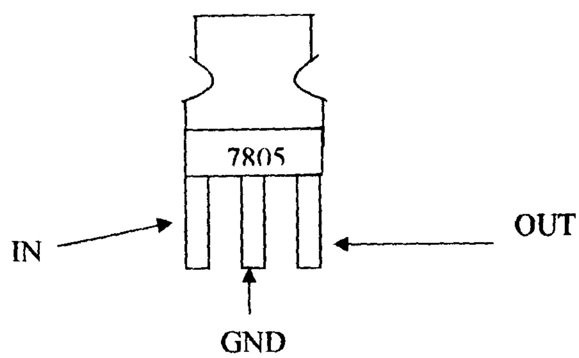

Fig 3.2: Diagram of 7805 regulator

The 7805 device is capable of sourcing 1A load current at an output voltage of 5V. the 5-volts DC was stabilized by a 3300μF capacitance before driving the control system.

3.2 LIGHT SENSING UNIT

The light sensor used was the LDR (light dependent resistor). An LDR exhibits an inverse resistance with increase in light level. The LDR was connected to a 555-based Schmitt trigger to provide snap action and oscillation-free response.

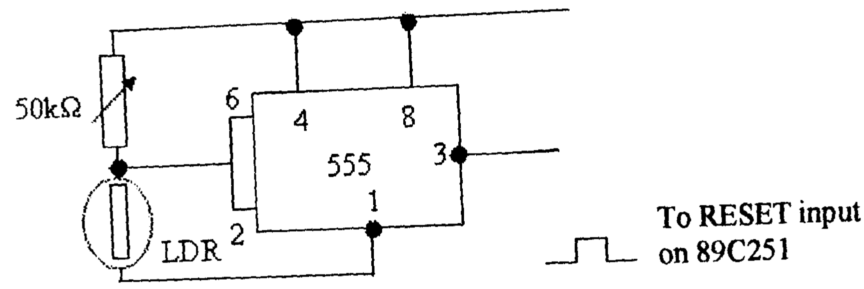

Fig 3.3: circuit diagram of the light sensing unit

The 555 has two internal components that switch at ⅓V_{CC} and ⅔V_{CC}. in the Schmitt trigger mode, pin 6 and pin 2 are connected together and supplied with an input voltage.

When $V_{(2, 6)}$ > ⅔V_{CC}, the output (pin 3) is low and remain low until $V_{(2, 6)}$ drops below ⅔V_{CC}, at which point pin 3 goes high. A 50kΩ preset point potentiometer wired in series with the LDR adjusts the sensitivity of the light detector stage. The potential divider network is shown in fig 3.4

The voltage-light relationship for the system shown above is indicated below:

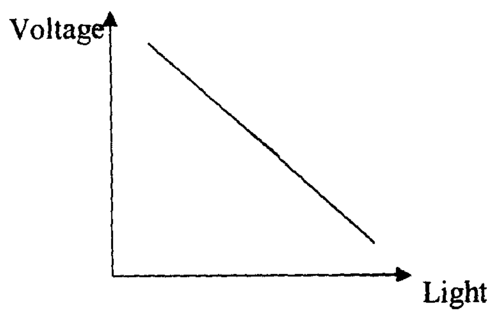

Fig. 3.4: voltage-light output relationship

Pin 3, the output of the 555 is connected to the RESET input on the 89C2051. the microcontroller is reset when the light level around the sensor is high, the controller therefore does nothing. When the light level falls below the present level, pin 3 goes low and the microcontroller starts executing the system control routine stored in its on-clip FLASH memory.

3.3 SYSTEM CONTROLLER UNIT

The system controller is an AT89C2051 microcontroller with 8-bit architecture and 128 byte of RAM. It was programmed in assembly language. It executes the system control software that:

i Responds to user time presets

ii Deactivate the connected load when the preset time expires (in the absence of light falling on the LDR).

The system controller executes the software when RESET goes low. A default time-out of 60 minutes is loaded at power up. If the user does not change this value, the controller disconnects the load after 60 minutes. However, if light is sensed, the controller is reset and the timing sequence starts anew. The time-out delay can be adjusted from 0 to 99 minutes via two push bottoms connected to the INT0 and INT1 inputs on the microcontroller.

The microcontroller switches the load via one of its output pins. The output pin drives a relay through a PNP transistor as shown in fig 3.7.

3.4 VISUAL DISPLAY UNIT

A 2-digit 7-segment display system was used. Multiplexing was used to reduce the amount of wiring needed.

Multiplexing involves turning on a digit for a specified period of time, turning it off and turning on a different unit. If the multiplex frequency is high enough, a persistence of vision is created and the eyes cannot notice the multiplex.

Multiplexing involves the basic steps listed below:

i Turn off both digits

ii Turn on digit 1

iii Delay for persistence

iv Turn off digit 1

v Turn on digit 2

vi Delay for persistence

vii Turn off digit 2

viii Repeat 2 – 7.

The multiplex unit is shown below

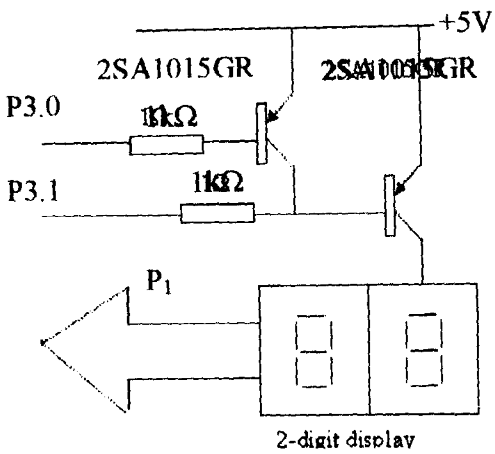

Fig. 3.5: Circuit diagram of 2-digit visual display unit

When displays are not multiplexed, the nominal segment current is increased to I_f x the number of digits. Displays with 30mA forward current were used; therefore the segment current is 60mA. The value of base resistors was chosen to source this current at the transistor's collectors.

The peak voltage is:

(2 x 7 x 30) = 420mA

$$I_C = \beta I_B;\ I_B \qquad 3.5$$

$$= \frac{0.42}{300} = 1.4mA$$

$$R_b = \frac{V_B - V_{be}}{I_B} \qquad 3.6$$

$$= \frac{5 - 0.7}{0.0014} = 3k\Omega$$

An overdrive factor of 3 was used to keep heat loss in the driver transistors. R_b was therefore made 1kΩ. the segment current issue through port 1 of the controller which provides a return path to ground

3.5 OUTPUT INTERFACE UNIT

The PNP transistor is switched on when P3.7 goes low under software control as shown below:

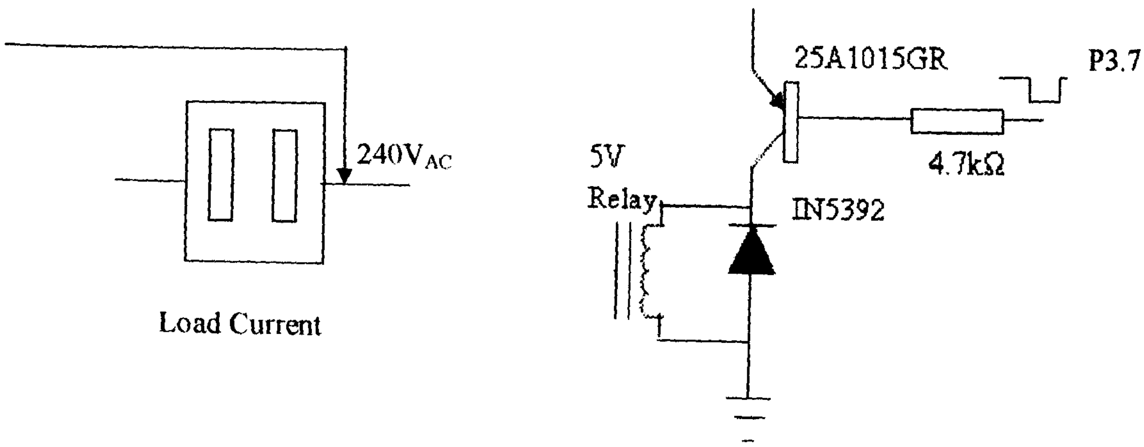

Fig 3.6: Circuit diagram of load power output control

When P3.7 goes low, a voltage (V_{CC} – $V_{CC\ sat}$) appears on the collector of the transistor to energize the relay. The base resistor is chosen based on the relay current. A 5V, 5A 400Ω coil was used. $I_C = I_L = \frac{5}{400} = 0.0125A$

$H_{fe} = 300$

$$I_C = \beta I_B \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad 3.7$$

$$I_B = \frac{I_C}{\beta} = 42\mu A \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad 3.8$$

$$R_b = \frac{V_B - V_{be}}{I_B} \quad (9)$$

$$= \frac{5 - 0.7}{42 \times 10^{-6}} = 103k\Omega$$

An overdrive of 20 was implemented, cutting R_b to 4.7kΩ. Overdriving minimizes the amount of heat dissipated in the collector-emitter junction of the PNP transistor

When the relay energizes, the normally (lose (N/C) contacts open and power deliver to the load is interrupted.

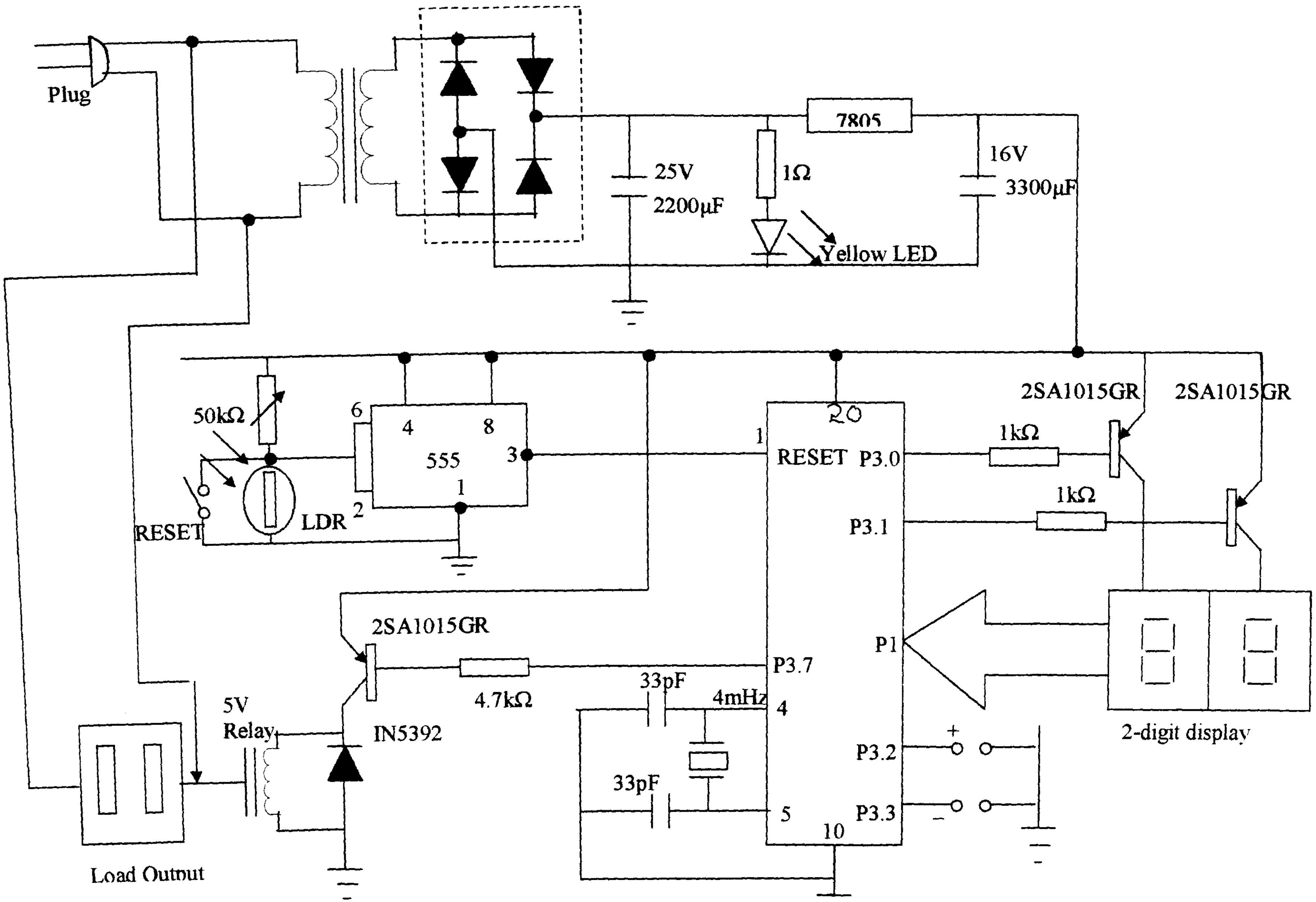

Fig. 3.7: Functional Circuit Diagram of the Light Dependent automatic-off timer of a CD player

CHAPTER FOUR

TEST, RESULTS AND DISCUSSION

Testing is carried out primarily to see if the actual performance of the newly constructed device matches its expected performance. This makes it possible for the designer to estimate the accuracy of the fabricated device. Likewise also, the testing of the automatic-off light dependent timer for CD players was necessary for the simple reason stated above.

4.1 TEST

A smaller time-delay period of about 2 minutes, was used as test mode in predicting the actual operation of the device in the "operation mode."

A simple digital stopwatch was the tool required for the testing of the device. In order to test, the device was simple powered on and its operation mode was set to the test mode. With the LDR was covered to stimulate a dark environment, the associated time delay was displayed on the seven-segment LED display and the record was taken by means of a stopwatch. This process was also repeated for the operate mode.

4.1.1 RESULT

Results gotten during the test exercise were tabulated as follows:

Mode Of Operation	Actual Time Delay	Expected Time-Delay
Test	2.0 minutes	2.0 minutes
Operate	60.0 minutes	60.0 minutes

4.2 DISCUSSION OF RESULTS

From the results displayed in table 4.1, we see that there was no discrepancy between the actual time-delay period in operation and the expected time-delay period.

CHAPTER FIVE

CONCLUSION

5.1 SUMMARY

Timers are very important part of many electronic and digital circuits as timing based control is the basic function of many modern control sub-systems and systems. More so, timers are commonly employed to initiate an action or trigger an operation after a set-time delay elapses. There is no.limit to the versatility of this family electronic device offer modern engineering design.

The device constructed is actually unique timer whose timing control is dependent on light intensity. This is because, the light dependent automatic-off timer is primarily to aid users who arbitrary listen to music late in the night, by producing a safe automatic means to switching off CD players in a case where the user falls asleep suddenly.

Conclusively, since the objective of the design is met and the fabricate design works normally as expected, this project work/experience is considered successful, rewarding and fulfilling.

5.2 RECOMMENDATION

The operation of this device could be applied to not just CD players but common household electronic appliances like the Television. Maximum timing delay of 99 minutes. The limitation can be removed by modifying the software.

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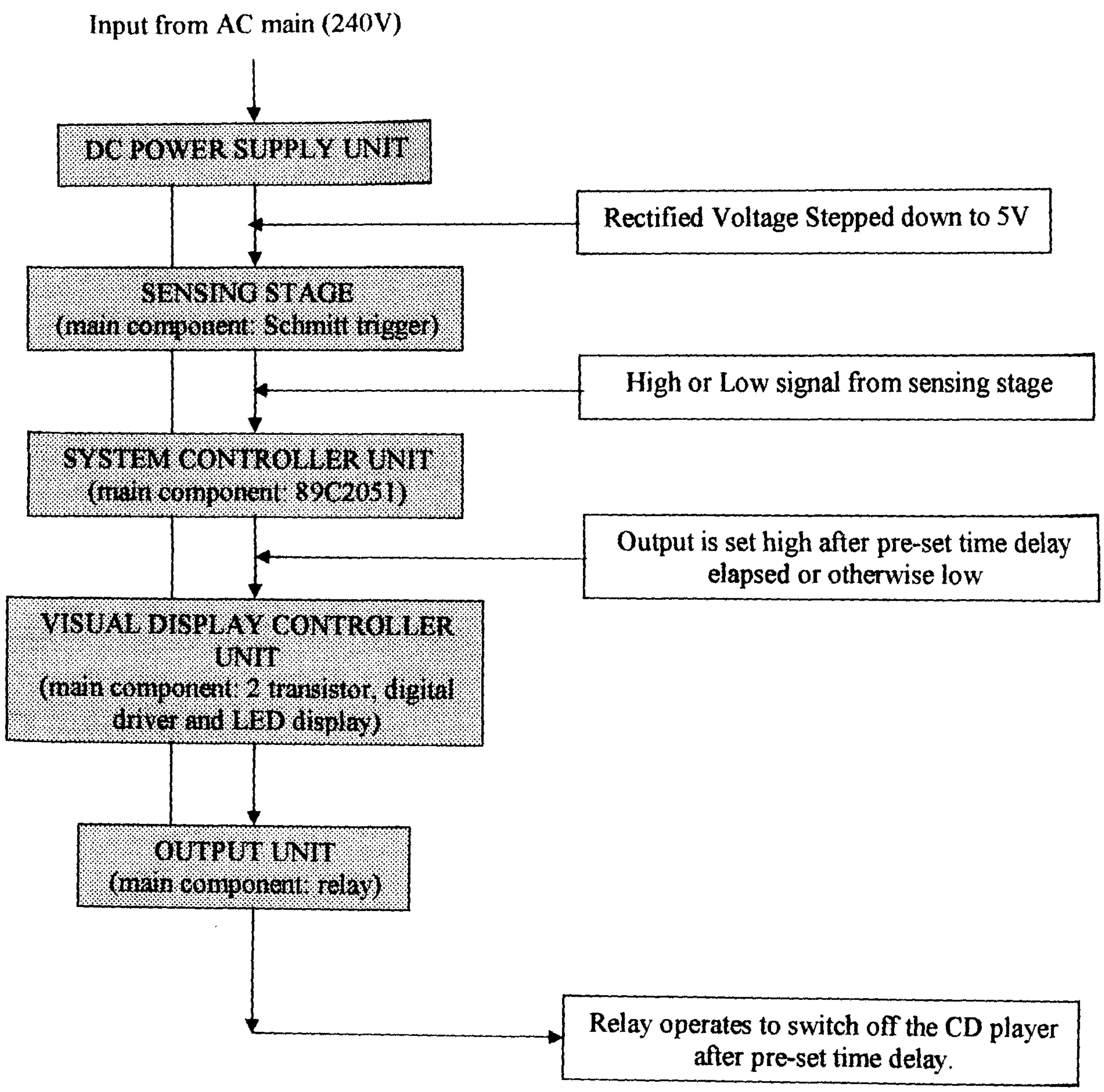
APPENDIX A

BLOCK DIAGRAM OF THE SYSTEM



Key:

- Downward arrows show the direction of logic and signal flow
- Text boxes highlights the state of signal between the blocks

APPENDIX B

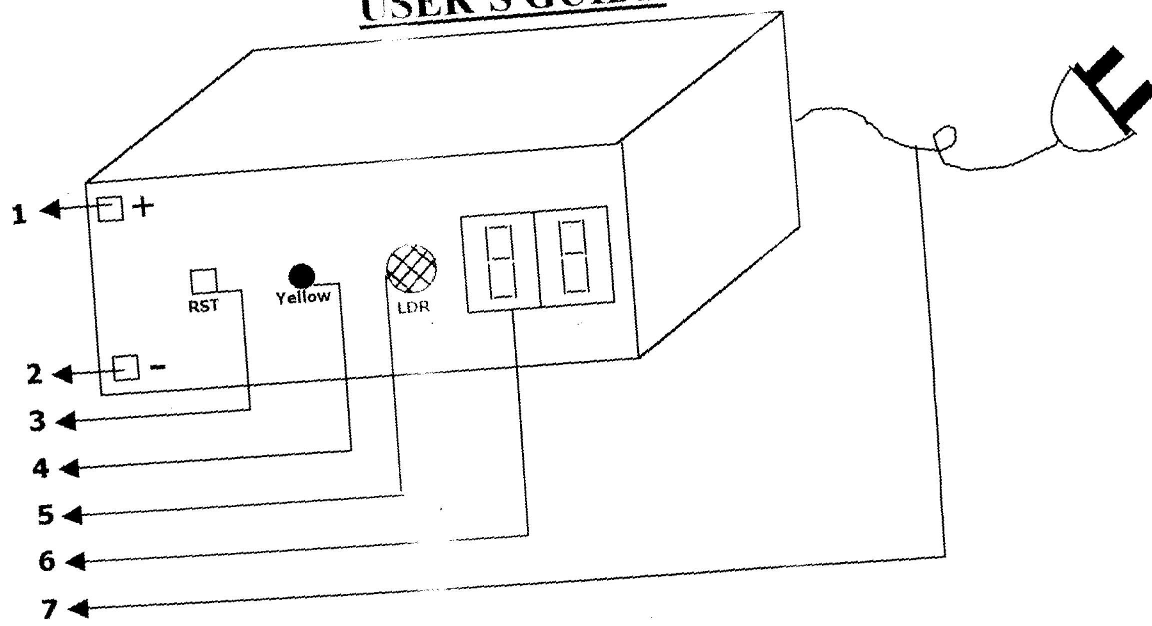
LIST OF COMPONENTS USED IN THE PROJECT WORK

COMPONENT TYPE	QUANTITY
RESISTORS	
1kΩ	3
4.7kΩ	1
50kΩ	1
LDR	1
CAPACITORS	
2200μF (25v)	1
3300μF (16v)	1
33 pF	2
DIODES	
144001	4
145392	1
LED (indicator)	1
LED Visual Display	2
2SA1015GR Transistor	3
Relay (N/C) 5V	1
Transformer (12V, 0.3AS)	1
2 pin socket	1
AT89C2051 Microcontroller	1
555 timer and crystal ($4MH_3$)	1 each

Notes: The light dependent automatic-off timer for CD players must be operated within the range of 220V-240V_{AC}

- When one of the 2-digit displays goes ON and OFF, it means the voltage is low and when the preset time elapses, it can't disconnect the connected electronic appliance at the output interface.
- It must be kept in dry place

USER'S GUIDE



LIGHT DEPENDENT AUTOMATIC OFF TIMER FOR CD PLAYERS

- Increase timing (1)
- Decrease timing (2)
- Reset function (3)
- Power indicator (4)
- Light dependent resistor, LDR (5)
- 2 – digit display (6)
- Plug cord (7)

HOW IT OPERATE

Connect the light dependent automatic off timer to A.C power supply (240VAC The yellow indicator (4) shows the presence of power supply. Connect a player to the output interface of the device.

- When the room is sufficiently dark, the sensor (5) will have high impedance which will inturn pass a high voltage into the input o Schmitt trigger. The Schmitt trigger bing a logic inverter will pass signal to reset the micro controller. long as light is detected, the micro-controller is reset. When light fails, the 555 timer output goes low and the micro controller starts executing the system routine stored on its on-chip FLASH memory. The micro controller keeps track of time by counting how-many micro seconds have elapsed since coming out of *reset* mode. After every 60 seconds, a variable minute is decremented. When minute is Zero, the CD that was initially ON is switched off after 60 seconds.

- Button 1 is used for increasing the timing
- Button 2 is used for decreasing the timing
- Button 3 is used to reset the timing.

Precaution

1. Must be kept in a dry place
2. Must be operated within the range of 220 – 240 volts (AC)
3. It should be dusted with dry cloth to avoid shock