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DESIGN AND CONSTRUCTION OF A HIDDEN/MISPLACED ACTIVE CELL PHONE DETECTOR

Rejoice Chisom Law-Obi[1], *Isaac Amazuilo Ezenugu[1*], Johnpaul Uzoho[1]
Fidelia Nwanneka Law-Obi[2], Darlington Valentine Opurum[3]

[1]Department of Electrical/Electronic Engineering, Faculty of Engineering, Imo State University, Owerri, Nigeria.

[2]Department of Industrial and Technology Education, Faculty of Vocational and Technology Education, Alvan Ikoku Federal University of Education, Owerri, Imo State, Nigeria.

[3]Department of Statistics, School of Physical Sciences, Federal University of Technology, Owerri, Nigeria.

*E-mail address: lawobichisomrejoice@gmail.com

ABSTRACT

Due to the challenges posed by ‘‘Frisking Method," the use of misplaced/hidden active cell phone detector is used to overcome such challenges. The threat posed by cell phones in correctional facilities and companies has caused companies to lose significant amounts of money. One very effective way of countering the dangers caused by the use of cell phones in correctional facilities and companies is through the use of misplaced/ hidden active cell phone detector. This detector is capable of detecting the presence of activated mobile phones from a distance of up to one meter. Using a varactor diode as input reactive component, a tuned circuit can be formed as input to a current depended operational amplifier to pick up cell phone frequencies ranging from 750MHz of 2G network to 3GHz of 4G network. The block diagram of the system was generated to give me a better understanding of the system function and help create interconnection within it.

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The design project is divided into eight blocks or units.The power supply unit, the RF/detector unit, the pre-amplifier unit, the voltage amplifier unit, the low pass filter unit, the voltage reference unit, The voltage comparator unit and the output unit. The circuit can detect the incoming and outgoing calls, even if the mobile phone is kept in the silent mode. The moment the Bug detects RF transmission signal generated from another mobile phone, it produces visual and audio alerts. The alerts continue until the signal transmission ceases. The phone detector can be effectively used in sniffing out hidden phones active and in use at prohibited areas – examination halls, churches, sitting courts, etc.

Keywords: Cell phones, cell phones detector, frequency, jammers, varactor diode, buzzer, transmission, signal, circuit diagram, technique.

1. INTRODUCTION

Cell phones have become an integral tool for communication. They are not only used for communication via short messaging service (SMS), calls, emails and internet but advanced applications such as remote health systems have been integrated with mobile phones but in recent times, the usage of cell phone has posed much threat despite the advantages enjoyed by these advancements in mobile technology (Shradha Jha, 2018). Cell phones have the ability to emit strong electromagnetic energy affecting the functionality of vital medical equipment. Life support machines are sensitive to the use of mobile phones (Periyasamy M.M et al, 2016). The use of mobile phones in such a facility leads to adverse repercussions to the life of persons whose lives depend on the proper functionality of the machines; therefore, the use of cell phone should be avoided in the hospital/ health care centers. (Ally S.N & Nixon M, 2014) has indicated that the use of cell phone by students in the examination hall in order to browse the internet and find solutions to the problems given, so as to get good grades and this has affected the educational system in this country so badly. This issue of the usage of cell phones in examination halls give rise to "Frisking'' due to there was no technology to detect the cell phones in the examination halls. Frisking is the process of using your hands to search someone's body while putting on clothes in order to see if they are hiding illegal objects or other prohibited items. Students undergo frisking as they enter the examination venues by invigilators. Frisking is gender-sensitive and people feel that their privacy is infringed. It is beyond one's imagination of what can happen when there is no female staff to frisk the female students which is mostly the case in the school of engineering. This is not saying that only female students are prone to carry their mobile phones into the examination halls, but it opens doors for gross irregularities as the contents of these gadgets can be easily shared via messages and Bluetooth. In the quest to find a solution to this problem gave birth to the topic of this project that says "Design and construction of hidden/misplaced active cell phone detector.". (Bukar B.A et al, 2019) defined Cell phone detector as a handy mobile phone bug, pocket-size mobile transmission detector, or sniffer that can sense the presence of an active mobile cell phone from a distance of one and a half meters. So, it can be used to prevent the use of mobile phones in examination halls, confidential rooms, and so on. The dimensions of cell phones have shrunk dramatically in the intervening years, while their capabilities have grown exponentially, as has cell phone ownership. Their sophistication and ubiquity pose many security challenges, and have given rise to a demand for equally sophisticated cellular phone detection and detecting the use of mobile phones for spying and unauthorized video transmission.

How Cell Phone Works: Imagine calling a friend on the side of the town. As you chat away, your phone converts your voice into an electrical signal, which is then transmitted as radio waves and converted back into sound by your friend's phone.

A basic mobile phone is therefore little more than a combined radio transmitter and radio receiver, quite similar to a walkie-talkie or CB radio. In order to remain portal, mobile phones need to have relatively compact antennas and use a small amount of power.

The cellular network divides up land into a patch work of "cells"- hexagonal areas of land each equipped with their own phone mast (also called the base station). This allows you to talk to your friends regardless of how far away your friends are. The huge phone masts pick up the weak signal from your phone and relay it onwards to another phone mast nearer to your friend. And if you're on the move while you talk, your phone switches masts as you go without interrupting your cell (Cudjoe Dan, 2014). These cell phone detectors use different techniques to operate. Each manufacturer has their design, although the basic procedure how the detection is done may be common.

Frequency Jamming: Jammers work by giving a RF signal or a signal at the same frequency expected by the device that's being jammed, but at a higher power compared to the targeted signal. The jamming signal itself is usually a random noise. The device being jammed will then receive the higher power signal which is from the jammer, and then the devices can no longer function correctly. Jammer can have one or multiple frequency signal. The output power of the jammer device will typically be stated in WATTS or in some cases DBM, (decibels per meter), or both.

There are several ways to jam a RF signal.

Spoofing: In this method, the mobile phone is been detected, and the jamming device sends a signal to disable the mobile phone or sends a message to the user of that phone to switch it to the silent mode.

Shielding attacks: This is EMF shielding of the mobile phone signal, in which phone cannot transmit or receive any RF signal from outside.

Denial of service: In this DOS technique, the device transmits a noise signal at the same operating frequency of mobile phone in order to decrease the SNR of the mobile. This is the simplest technique and is very common (S.K Bhatia et al,2015).

Therefore, one of the methods to detect the mobile phone is to have another device transmitting at the same frequency as the mobile phone but at higher power level. As the phone signal is interfered by the device, service on the phone is blocked. Since the phone may be moving around and therefore its signal handed over from one base station in a cell to another, the jamming device performs well when placed in between the two cells to ensure total denial of service. The jamming device overpower the cell phone by transmitting a signal on the same frequency and at a higher enough power that the two signals collide and cancel each other out. This mobile detector system with frequency jamming features can sense the presence of an activated mobile cell phone from a distance. So, it can be used to prevent the use of mobile phones in examination halls, confidential rooms, etc. Cell phones are a full-duplex device which means they use two separated frequencies, one for talking and one for listening simultaneously. Some jammers block only one of the frequencies used by cell phones, while some have the effect of blocking both. The phone is tricked into thinking there is no service because it can receive only one of the frequencies. The mobile detector system with frequency jamming feature will be able to jam mobile phone frequency signal upon detection to prevent the transmitted signal from getting to the user's cell phone, a mobile phone jammer actually prevents its use even if it is just switched on by overpowering any network signals. Mobile jammer is used to prevent mobile phones from usage, receiving, or transmitting signals with the base stations. Mobile jammers effectively disable mobile phones within the defined regulated zones without causing any interference to other communication means. Mobile jammers can be used in practically any location but are used in places where a phone call would be particularly disruptive like temples, libraries, hospitals, cinema halls, schools & colleges etc (Oke A.O, Falohun A.S & Adigun A.A, 2016).

As with other radio jamming, mobile jammers block mobile phone use by sending out radio waves along the same frequencies that mobile phones use. This causes enough interference with the communication between mobile phones and communicating towers to render the phones unusable (Shantanu K.M & Vimala C, 2014). Upon activating mobile jammers, all mobile phones will indicate "NO NETWORK". Incoming calls are blocked as if the mobile phone were off. When the mobile jammers are turned off, all mobile phones will automatically re-establish communications and provide full service (Swathy P.G., 2015). The disadvantage of this technique is that cell phones in the jammed locality can still be used for other services such as data mining, which pose a very big problem in companies. In the case of examination halls, the phone smuggled can be used in examination irregularities despite having a jammer in the hall. This method, therefore, proves to be ineffective in cases where cell phone usage is prohibited **(**Mwango A.N., 2016).

This project is limited to the detection of cell phones that is active and on silent mode; switched off or airplane mode will not be included in this project. This device detects its presence active cell phone by alarming the sound and the blinking of the Light Emitting Diode. The device is sensitive to a range of frequencies. GSM frequencies within 900MHz to 1200GHz are most appropriate, and that is basically the 3G family of frequencies. At 4G range of frequencies, the device will be selective. The project distance of the hidden phone to the device will be between 100cm to 200cm radius of coverage.

2. MATERIALS AND METHODS

Most of the materials used for the design are discrete electronic components, both passive and active type. The passive components include resistors, diodes, and capacitors used mainly for signal control and direction, while the active components are the transistors and integrated circuit ICs used for amplifications and the auto switching operations. The major feature of the design is the use of a varactor diode in detecting the high frequency at the input unit. And for clear visual identity, one LED is used for power indication, while another is activated only when there is the presence of a transmitted GSM signal.

2.1. DC Battery

DC batteries, also known as constant current, which is, a DC that does not change in size and direction, such as dry cells. Batteries produce something called direct current (DC). The positive and negative terminals of a battery are always, respectively, positive and negative. Current always flows in the same direction between those two terminals. DC batteries provide power to protective relays, breaker trip circuits, and other vital control systems (Mose R & CBS F.S 2022).

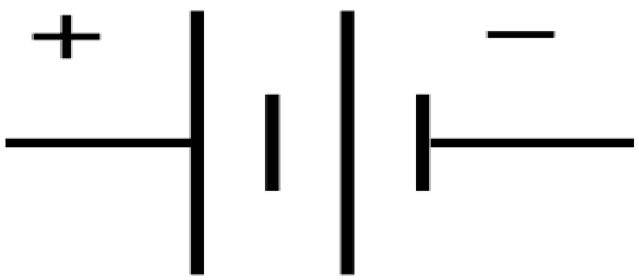

Figure 1. Basic circuit symbol of a battery.

2.2. Zener diode

Zener diodes are semiconductors that permit current to flow in both directions, although they excel at allowing current to flow in the opposite way. The most popular electronic component used as a steady voltage reference for electronic circuits is a Zener diode, also referred to as a breakdown diode. The Zener effect is the phenomenon of reverse-biased (backward) current flowing across terminals. This results in the breakdown voltage (Vz) or zener voltage (Vz) when voltage potential is reached. Uniquely, Zener diodes have a P-N junction that is strongly doped, allowing current to flow in reverse when it reaches Vz. Unharmed by reverse bias, a well-defined Vz can conduct current constantly. Following a peak current level set by a series resistor, the current stabilises and remains constant throughout a variety of applied voltages. Zener diodes can therefore be used as voltage regulators (Shreya M, 2023).

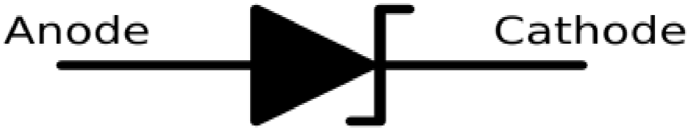

Figure 2. Basic circuit symbol of a Zener diode.

2.3. Capacitor

Capacitor is a device which can hold or store electric charge. A capacitor is made of two conductors, such as parallel metal plates of cross-sectional area (A) separated from each other by distance (d). An insulator is placed between the conductors or parallel metal plates. There is a dielectric material separating the parallel plates. A dielectric material is defined as an insulator in which an electric field can be sustained with a minimum dissipation of power. In a dielectric material, there are no mobile electrons necessary for electrical conduction. Examples of dielectric materials include Vacuum, Air, Glass, Wood, Mica, Paper, Nylon, Mineral Oil, Rubber and Paraffin wax (Abdul R.A.Z, 2021).

2.3.1. Electrolytic capacitor or polarized capacitor

All electrolytic capacitors (e-caps) are polarized capacitors whose anode (+) is made of a particular metal on which an insulating oxide layer forms by anodization, acting as the dielectric of the electrolytic capacitor. A non-solid or solid electrolyte which covers the surface of the oxide layer in principle serves as the second electrode (cathode) (-) of the capacitor. Due to their very thin dielectric oxide layer and enlarged anode surface, electrolytic capacitors have, based on the volume, a much higher capacitance-voltage (CV) product compared to ceramic capacitors or film capacitors, but a much smaller CV value than electrochemical super capacitors. The large capacitance of electrolytic capacitors makes them particularly suitable for passing or bypassing low-frequency signals up to some megahertz and for storing large amounts of energy.

They are widely used for decoupling or noise filtering in power supplies and DC link circuits for variable-frequency drives, for coupling signals between amplifier stages, and storing energy as in a flashlamp. Standard electrolytic capacitors are polarized components due to their asymmetrical construction, and may only be operated with a higher voltage (i.e., more positive) on the anode than on the cathode at all time. Voltages with reverse polarity, or voltage or ripple current higher than specified (as little as 1 or 1.5 volts may suffice), can destroy the dielectric and thus the capacitor. The destruction of electrolytic capacitors can have catastrophic consequences (explosion, fire). (Sawsan A.E.A. & Mubarak D.A., 2016).

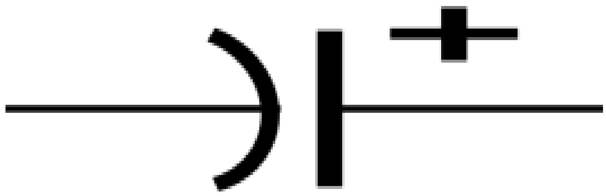

Figure 3. Basic symbol of a polarized capacitor.

2.3.2. Non-Polarized Capacitor

Non-polarized capacitors is also called non-electrolytic capacitors. These are capacitors with neither positive nor negative polarity. Non-polarized capacitors' two electrodes can be put into the circuit at random and will not leak. They're typically found in the coupling, decoupling, compensation, feedback, and oscillation circuits. The non-polarized capacitor is mostly utilized in coupling, decoupling, feedback, compensation, and oscillation circuits (Linquip Team, 2021).

Figure 4. Basic symbol of a non-polarized capacitor.

2.4. LED

A two-lead semiconductor light source, the light-emitting diode produces light. The LED is a unique kind of diode with electrical properties that are comparable to those of a PN junction diode. Consequently, the LED permits electricity to flow in one direction while blocking it in the other. LEDs are employed in a variety of electrical and electronic projects. A p-n junction diode serves as the light-emitting diode. It is a unique form of semiconductor and a particularly doped diode. A light emitting diode is one that produces light when it is forward-biased. LEDs find applications in various fields. They are used as light bulbs to display the message, these are utilized in mobile phones, it finds usage in many areas because of its small size and affordability (Shreya M, 2023).

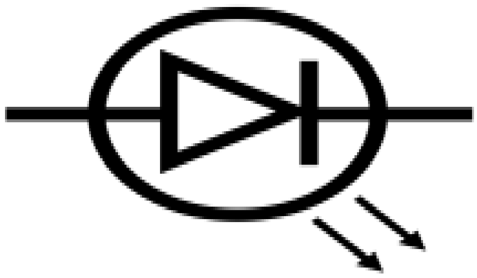

Figure 5. Basic symbol of a LED.

2.5. Voltage Regulator

There are mainly two types of voltage regulators: Linear voltage regulator and switching regulator. Both types of voltage regulators regulate the voltage of the system but the linear voltage regulator operates with low efficiency than the switching voltage regulator. There are mainly three components that consist in voltage regulators. They are: Feedback circuit, Stable Reference Voltage, and Pass Element Control Circuit.

2.5.1. Linear Voltage Regulator

A voltage regulator provides this constant DC output voltage and contains circuitry that continuously holds the output voltage at the design value regardless of changes in load current or input voltage (this assumes that the load current and input voltage are within the specified operating range for the part). A linear regulator operates by using a voltage-controlled current source to force a fixed voltage to appear at the regulator output terminal. The control circuitry must monitor (sense) the output voltage, and adjust the current source (as required by the load) to hold the output voltage at the desired value. The design limit of the current source defines the maximum load current the regulator can source and still maintain regulation. The output voltage is controlled using a feedback loop, which requires some type of compensation to assure loop stability. Most linear regulators have built-in compensation, and are completely stable without external components. Some regulators (like Low-Dropout types), do require some external capacitance connected from the output lead to ground to assure regulator stability. Another characteristic of any linear regulator is that it requires a finite amount of time to "correct" the output voltage after a change in load current demand. This "time lag" defines the characteristic called transient response, which is a measure of how fast the regulator returns to steady-state conditions after a load change (Chester S, no date).

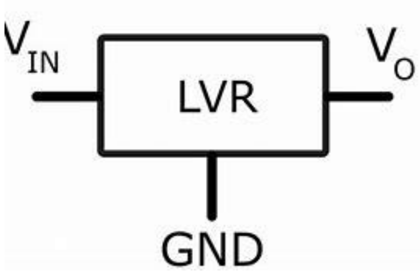

Figure 6. Basic symbol of a Linear voltage regulator.

2.6. Resistor

The resistor is a passive electrical component that renders resistance to electrical flow. The higher the resistance, the lower the current. In fact, resistance does not only affects the current, much more, voltage is also affected. Most commonly, resistors are made of the carbon film. Metal film and wire wound resistors and many more types, are also in use and some of them have special applications (Thomas G, 2017).

Resistors, both fixed and variable, are required in electronic circuits for variety of purposes. Fixed resistors are used in the biasing circuits of tubes and transistors, as load resistance for voltage amplifiers, in differentiating and integrating circuits, etc. Variable resistors find their use as level controls, as frequency determining elements of audio generators, as zero adjusting resistance of measuring instruments, and in a variety of other applications (P.K Verma, 2015).

Figure 7. Basic symbol of a resistor.

2.7. Varactor diode

Varactors, short for variable capacitors, play a pivotal role in electronic circuits by providing a means to dynamically control the capacitance in response to an external voltage. This unique property makes varactors indispensable in various applications, such as voltage-controlled oscillators, frequency synthesizers, and tunable filters (Mohamed G et al, 2024).

Varactor diodes are widely used within many RF designs. They provide a method of varying the capacitance within a circuit by the application of a control voltage.

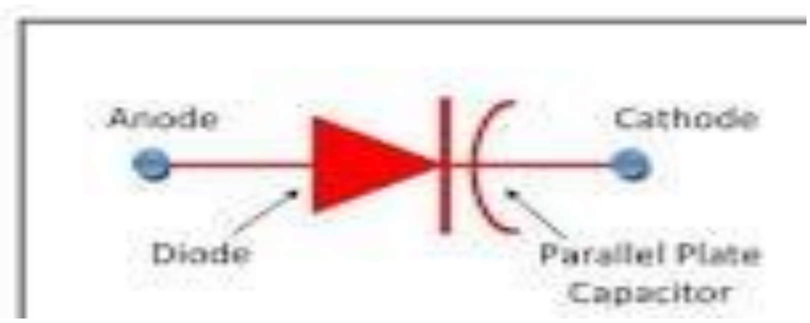

Figure 8. Basic symbol of a varactor diode.

2.8. Operational Amplifier

An operational amplifier ("OP-Amp") is a DC-coupled high-gain electronic voltage amplifier with a differential input, and usually, a single-ended output. An OP-Amp produces an output voltage that is typically hundreds of thousands of times larger than the voltage difference between its input terminals. Operational amplifiers are important building blocks for a wide range of electronic circuits. They had their origins in analog computers where they were used in many linear, nonlinear, and frequency-dependent circuits. Their popularity in circuit design largely stems from the fact that characteristics of the final Op-Amp circuits with negative feedback (such as their gain) are set by external components with little dependence on temperature changes and manufacturing variations in the Op-Amp itself. Op-Amps are among the most widely used electronic devices today, being used in a vast array of consumer, industrial, and scientific devices. The Op-Amp is one type of differential amplifier. A standard Op-Amp has a minimum of five pins for its operation. The basic pins are: V+ (non-inverting input), V- (inverting input), and Vout (output), VS+ (positive power supply) and VS- (negative power supply) The amplifier's differential inputs consist of a V+ input and a V- input, and ideally the Op-Amp amplifies only the difference in voltage between the two, which is called the differential input voltage. If the input given to the inverting Input (-) pin is less than the input given to the non-inverting input pin, then the Op-Amp output will be high. If the input given to inverting input (-) pin is more than the input given to the non-inverting input pin, then the output of the Op-Amp will be low. the output will be high and vice versa.

The use of an Op-Amp to provide safety for electronic device is very vital as it ensures the longevity of the electronic systems. The incorporation of Op-Amp inside an inverter system has a lot of advantages over the ones that does not have the Op-Amp feature, it also ensures that all the peripherals, battery for example, used with the inverter system are protected from damage that could result from overuse (Oluyamo S.S. & Olusola O.I., 2015).

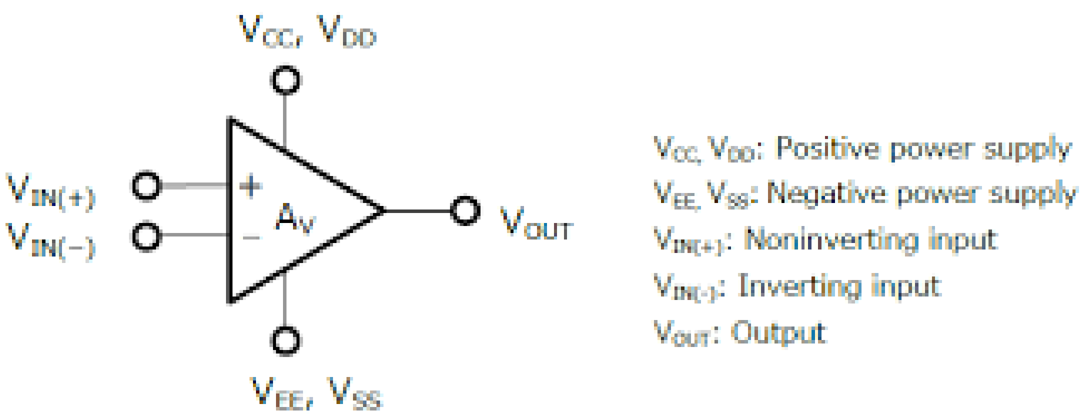

Figure 9. Basic symbol of an operational amplifier.

2.9. NPN Transistor

A BJT transistor that includes the NPN and the PNP transistor, the two N-type semiconductor pieces and one P-type semiconductor piece; which is called NPN transistor. The arrangement of semiconductor crystals is as follows.

In an NPN BJT, there are two negatively charged regions - the collector and the region Emitter- each with extra electrons. The discharge region is positively charged because it has extra holes. In an NPN BJT, the base-emitter junction is forward-biased and the base-collector junction is
reverse-biased. A small voltage is applied to the base region. A transistor has three bases named: emitter (E), base (B) and collector C (Maftunzada S.A.L, 2022).

The NPN transistor is made of three components or three main regions which includes: Emitter, Base and Collector. The base is region is very thin and is the region where two diodes are connected back-to-back. The diode on the left region is referred to as emitter-base diode. And, the diode present in the right side of the circuit is referred to as collector-base diode. The names of both diodes are as per the name of the region they are present in. The most essential component of this type of transistor is the lightly doped p-region (that is positive). And, the most densely doped region is the collector one. Emitter region is doped moderately when compared to collector and base region. While making the connections in the circuit, the emitter and base are connected in forward bias, while the collector and base region are connected in reversed bias. NPN transistors are used in amplifying circuit applications. NPN transistors are used in the Darlington pair circuits for amplifying weak signals. NPN transistors are used in applications we need sinking current. NPN transistors are used in some classic amplifier circuits, the same as 'push-pull' amplifier circuits. NPN transistor is used for interface switching component. The NPN transistor is represented, as shown below (Farhan S, 2017).

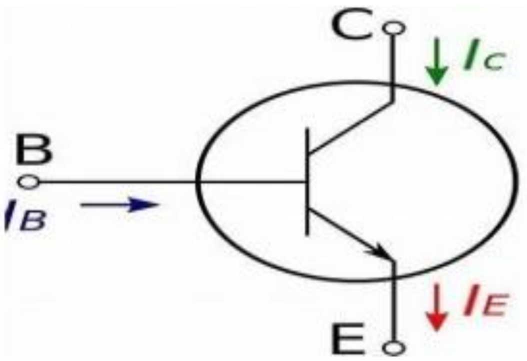

Figure 10. Basic symbol of a NPN Transistor.

2.10. Signal Diode

Signal diodes are small two-terminal which conducts current when forward biased and blocks current flow when reverse biased. The semiconductor signal diode is a small non-linear semiconductor device generally used in electronic circuits, where small currents or high frequencies are involved, such as in radio, television, and digital logic circuits. Generally, the PN junction of a small signal diode is encapsulated in glass to protect the PN junction, and usually have a red or black band at one end of their body to help identify which end is cathode terminal (Adel R, no date).

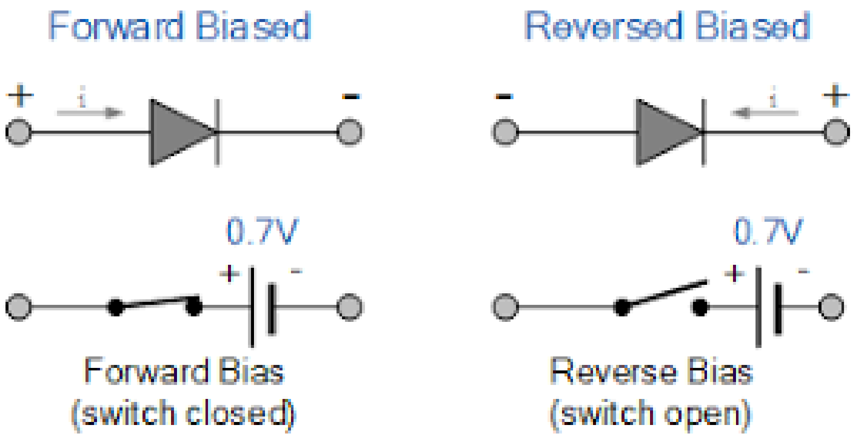

Figure 11. Basic symbol of a signal diode in a forward and reversed biased.

2.11. Potentiometer

A potentiometer is a three-terminal electrical component that can be used as a voltage divider or variable resistor. It contains a resistive element and a contact that can be moved to change the resistance. Some applications include dimmer switches for lights, brightness controls in televisions, and faders in audio equipment. There are several types of potentiometers that are classified in several ways. Linear and logarithmic potentiometers are classified by the relationship between resistance and length. Rotary and sliding potentiometers describe the movement of the wiper (Coralie N, Raghav M & Christianlly C, 2023).

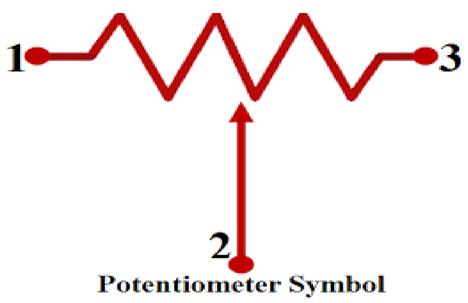

Figure 12. Basic symbol of a potentiometer.

2.12. Buzzer

A buzzer is an electronic component that can generate sound vibrations in the form of sound waves. The buzzer produces sound vibrations when supplied with a certain amount of electrical voltage by its specifications, shape, and size. Typically, buzzers are used as alarms due to their ease of use; simply by providing input voltage, the buzzer will generate sound vibrations in the form of audible sound waves (Ardiyallah A et al, 2023).

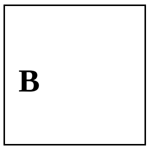

Figure 13. Basic symbol of a buzzer.

2.13. Methodology

The first stage of the work was to carefully choose or select the components suitable to implement the work. While selecting the components suitable to implement the work, I considered their functions, durability, consistency of performance, and their various ratings in order to avoid future hazards. The block diagram of the system was generated to give me a better understanding of the system function and help create interconnection within it. The block diagram helps to describe the hardware and software of the system as well as represent processes. Design calculations were properly done to obtain the values of the various components so as to avoid difficulties and challenges. Each of the block of the system was considered carefully, and the circuit diagram of each of the block was developed, on the successful completion of the circuit diagram of each block, another one was added accordingly until the output block in order to achieve the circuitry of all the block diagram. The functionality of the design was tested and analyzed through simulation process, this process enabled me to understand exactly how the design will perform in the real world, proper adjustments were carried out in order to make the design meet its expectation. Afterwards, component was tested and assembled carefully on a bread-board following the circuit design. During this time, all components were watched closely to find out if there were unnecessarily hot, inactivated or under-supplied with voltage. As expected, corrections were effected where any of these abnormalities were spotted. Unfortunately, on the first day of pre-testing after complete assembling of the circuit on breadboard, the output was totally nonexistent. It took days to discover that some coupling capacitors were mistakenly grounded. This prevented any signal from moving onto the next stage. Other minor corrections were spotted and corrections effected. All of these were carried out with patience and on different days. On completion of the entire circuit, it was powered, monitored, and the necessary examinations embarked upon. Then again, a full testing was conducted after safe powering of the assembled circuit. The results were as expected. A rectangular box 6X8 inches in dimension was used as the base structure that housed the Vero-boarded circuit. Accessories like On/Off switch, visual indicators and buzzer were externally mounted on the base panel. The buzzer is to be activated on receipt of GSM signal. From a side of the panel too was an extended antenna cable position to receive the super high frequency signal.

3. RESULT AND CONCLUSION

3.1. Preamble

This chapter deals with the design of the hidden/misplaced active cell phone detector, implementation of the design, and testing of the construction. The design involves hardware and software design.

3.2. Hardware System Design

The hardware system design was broken into various blocks or units as outlined below.

3.3. The Block Diagram

The design project is divided into eight units. The Power Supply Unit produces the power needs of the circuit, the RF/Detector unit detect and receives the transmitted cell phone signal, the Pre-Amplifier unit gives the received signal the first level of amplification, the voltage amplifier unit further increases the power strength of the signal, the low pass filter unit filters off the high frequency carrier while allowing the low frequency signal to pass onto the next stage, the voltage reference unit set up the reference voltage value from a voltage regulator circuit in this unit. The voltage comparator unit compares the reference voltage with the received low-frequency signal to produce an output, the output unit has an interface switching circuit that activates a DC-powered buzzer through the output of the comparator.
The block diagram is as shown in the figure below.

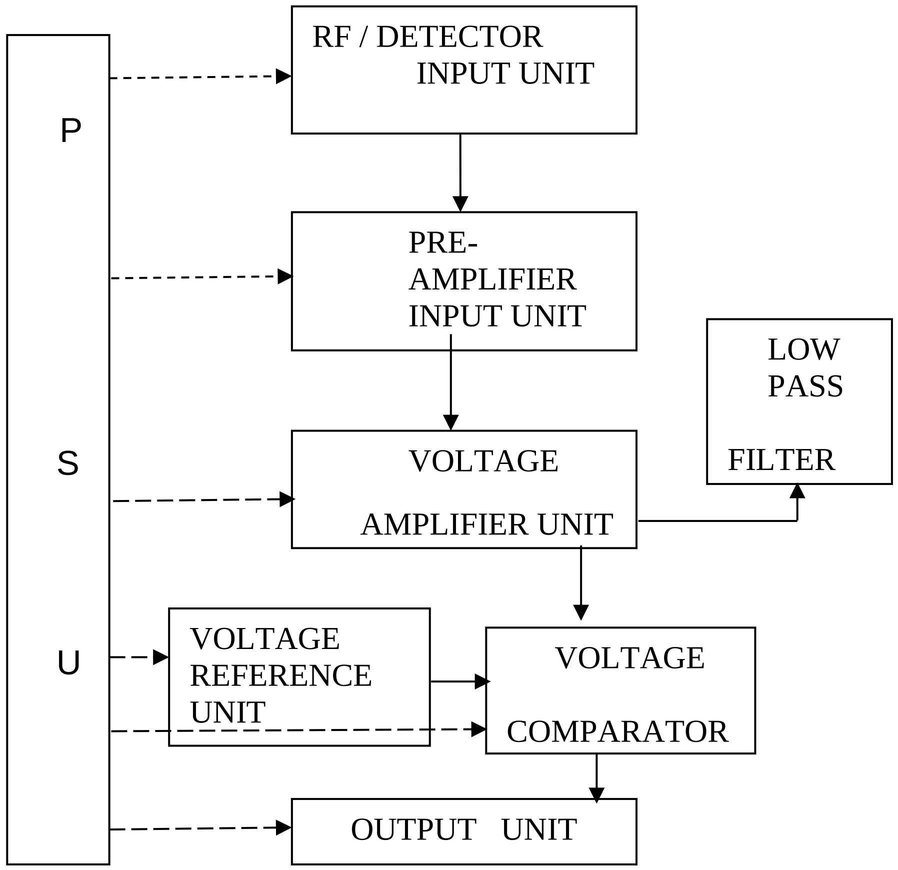

Figure 14. Block Diagram of the Complete Circuit Design.

3.4. The Design Analysis

3.4.1. The Power Supply Unit

This unit provides electrical power to the various sections of the circuit in order to function effectively. Because of the mobility nature of the device, a 9V battery was used for producing DC voltage to the required areas. A voltage regulating IC - LM7808C was used to help regulate the voltage to 8V output. Electrolytic capacitor C1 improved the DC quality content as a noise filtering component.

The Design Calculations

In calculating the value of the resistor used in protecting the LED indicator, the formula:

$V_{DC} = V_{R1} + V_{LED}$

$8 = V_{R1} + 2$

$V_{R1} = 8 - 2$

$= 6V$

Also, $V_{R1} = R1 \times I_{LED}$

Where I_{LED} was chosen to be 10mA

$$R_1 = \frac{V_{R1}}{I_{LED}}$$

$$= \frac{6V}{10 \times 10^{-3}A}$$

$$= \frac{6 \times 1000}{10} = 600\Omega$$

Standard value of R1 chosen with consideration was 1000Ω

The circuit diagram is as shown in figure 15 below.

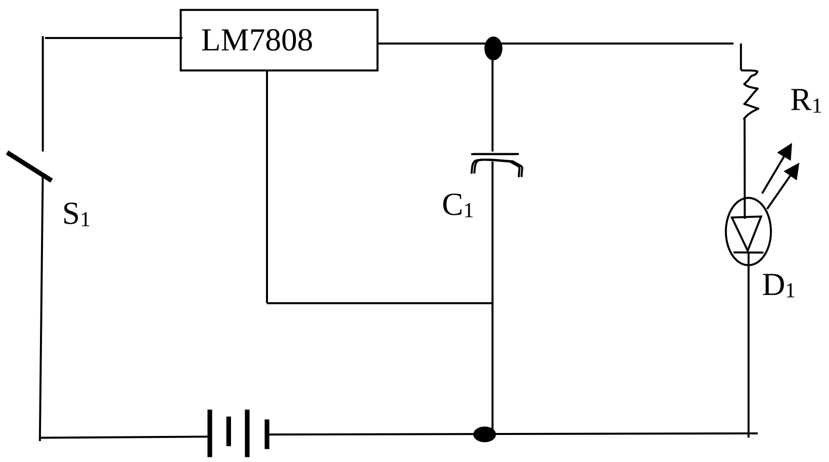

Figure 15. The Power Supply Unit.

3.4.2. The RF/Detector Unit

The unit receives the transmitted high frequency signal supposedly picked up by a nearby cell phone. This is made possible through non-electrolytic capacitor C2 of value 68pF. A varactor in tuned circuit with a capacitor C3 (22pF) allows only the very high frequency – which contains the GSM signal, to pass through. Low-frequency signal are easily grounded through the capacitor C3.

The circuit connections are as shown in the figure 16 below.

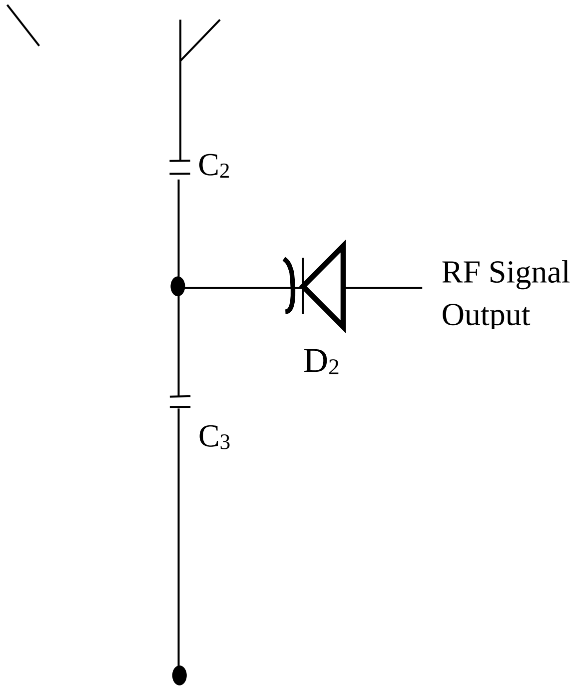

Figure 16. Circuit Diagram of the RF/Detector Unit.

3.4.3. The Pre-Amplifier Unit

Some level of amplification is given to the discovered, but weak signal, at this stage, after it has been detected. This amplification action is necessary in order to strengthen up the signal.in continuing the remaining circuit processes. The Pre-Amplifier unit is built around an Operational Amplifier – CA3130 which converts weak input current to an output in voltage form. Resistors R2 (10K) and R3 (120Ω) connected as a voltage divider circuit produces reference feedback (pin3) against the detected signal at the input (pin 2) of the pre-Amp. The gain of the amplifier is increased with capacitor C4 (22pF) connected between pin 1 and 8 of the IC. Once there is an input signal received, a current difference is caused at the input of IC1 resulting to a positive voltage output. Coupling capacitor C5 (2/2uF) will transmit the resultant output to the next stage.

The circuit connections are as shown in figure 17 below.

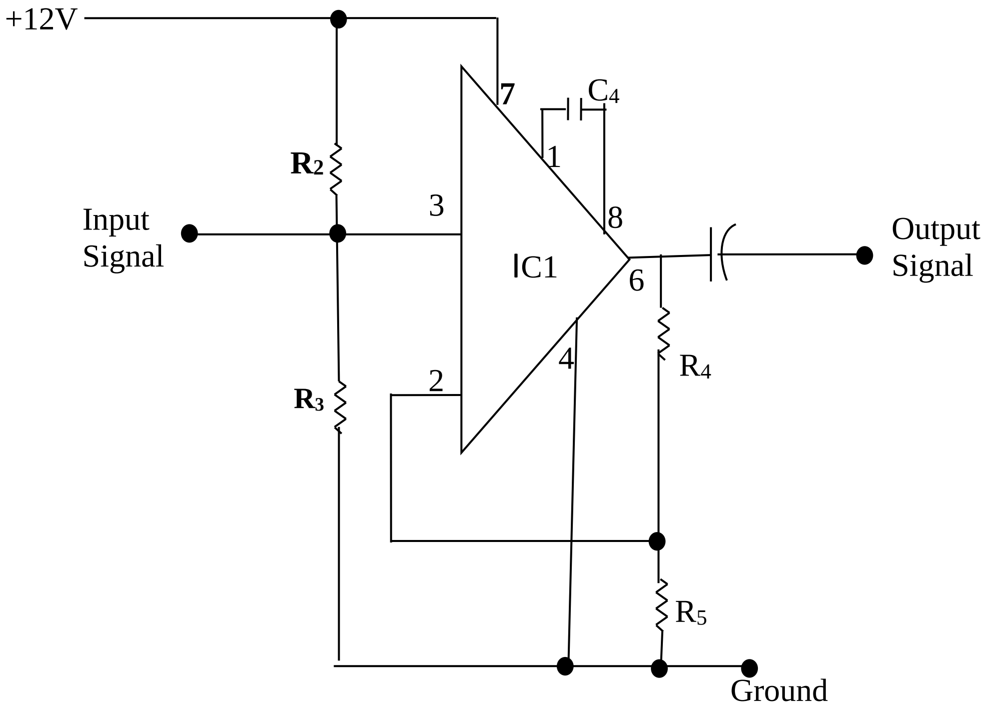

Figure 17. Circuit Connections of the Pre-Amplifier.

3.4.4. The Voltage Amplifier/Filter Unit

This unit was built majorly around an NPN transistor – Q_1, configured as a class A amplifier. The active component – Q_1, was universally biased to take in the input signal. The configuration was in common Emitter mode connection. The transistor has to be switched ON ready for the amplification of the received signal. Resistors R6 and R7 (at values of 6.2K and 1.5K respectively) were connected in a voltage divider format to provide the required biasing level for the transistor. The inter-stage coupling capacitors used for the pre-amplifier was C_5 (2.2μF in value). Output of the amplifier was converted to DC output voltage through signal diode D3 (1N4148). A decoupling capacitor, C_7(10μF) was also connected to bypass the A.C. signal present at the emitter region straight to ground. This helped in maintaining the D.C. biased arrangement of the amplifier. While the low pass capacitor C_6 (2.2pF in value) was connected R9 to filter off strongly the high frequency signal carried along.

The transistor used was NPN type – 2N2222. Table 1 below shows the parameter of the transistor from a semi-conductor data book.

Table 1. Parameter values of 2N2222 used for the amplifier unit.

Parameters	Values
B_{DC}	> 150
$P_{D\,max}$	0.5
$V_{CE\,max}$	60v
Cut off freq.	> 250mHz
$I_{C(max)}$	0.8A
Type	Silicon (NPN) – 2N2222

Design assumptions:

(1) $I_C \approx I_E$

(2) R_7= 2K, R_9= 1K

(3) $I_B \approx 100mA$

(4) $B_{DC} \approx 100$

(5) $V_{R7} \approx {}^1/_4$ of Vcc,

$V_{R3} \approx {}^1/_4$ of 12V = 3V

Using the formula

$B_{DC} = {}^{IC}/_{IB}$

$I_C = B_{DC} \times I_B \quad = 100 \times 100 \times 10^{-3}$

$I_C = 10mA = I_{R8}$

$Vcc = V_{R6} + V_{R7}$

$12 = V_{R6} + 3V$

$V_{R6} = 9V$

For R_6:

$V_{R6} = Vcc \times {}^{R6}/_{R6 + R7}$

$9(R_6 + 2000) = 12R_6$

$9R_6 + 18000 = 12R_6$

$R_6 = 6000$

R_2 = 6K, R_3 = 2K; Resistor R_8 is the load resistor taken to be 1.8KΩ

The circuit diagram is as shown in the figure 18 below.

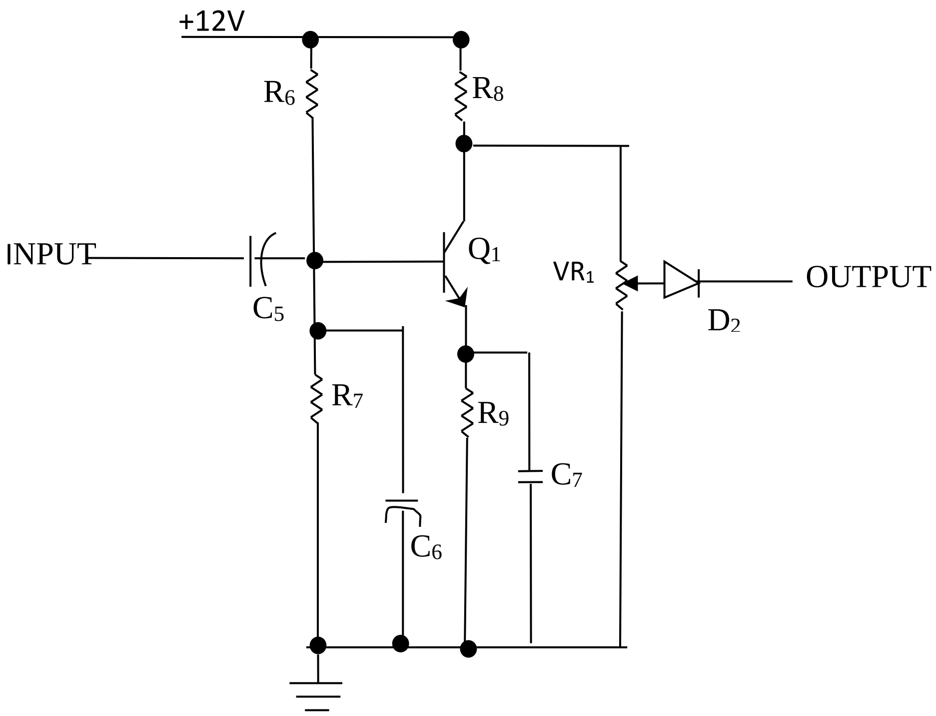

Figure 18. Circuit diagram of the Pre-amplifier.

3.4.5. The Voltage Comparator Unit

This unit changes the amplified, received, and processed RF signal to a discrete value of either 1 or 0. It is built around another Operational Amplifier, LF411C that uses only a single voltage supply for its activation. The unit is meant to compare two input values fed to its inverting and non-inverting terminals. It was connected in this circuit as a non- zero reference comparator. The non-zero reference of 2.7V was produced from a voltage divider circuit of zener diode D4 and resistor R10. This voltage served as the reference voltage fed to OP-AMP. The reference voltage is produced from across the zener diode and is connected to the pin 2 terminal of the IC2. The essence of the reference voltage is to reduce false triggering of the output unit. Until the arriving input signal is up to the value of 3V and above, (which will actually happen when the GSM signal has been received), that the IC will then compare and read it as higher value to the 2.7V fixed at pin 2. This positive difference will result in producing high voltage value of ‘1’ at the pin 6 terminal of the IC2. And except this happens, the voltage level output of the pin 6 will still remain low at 0V.

The circuit diagram is as shown in figure 19.

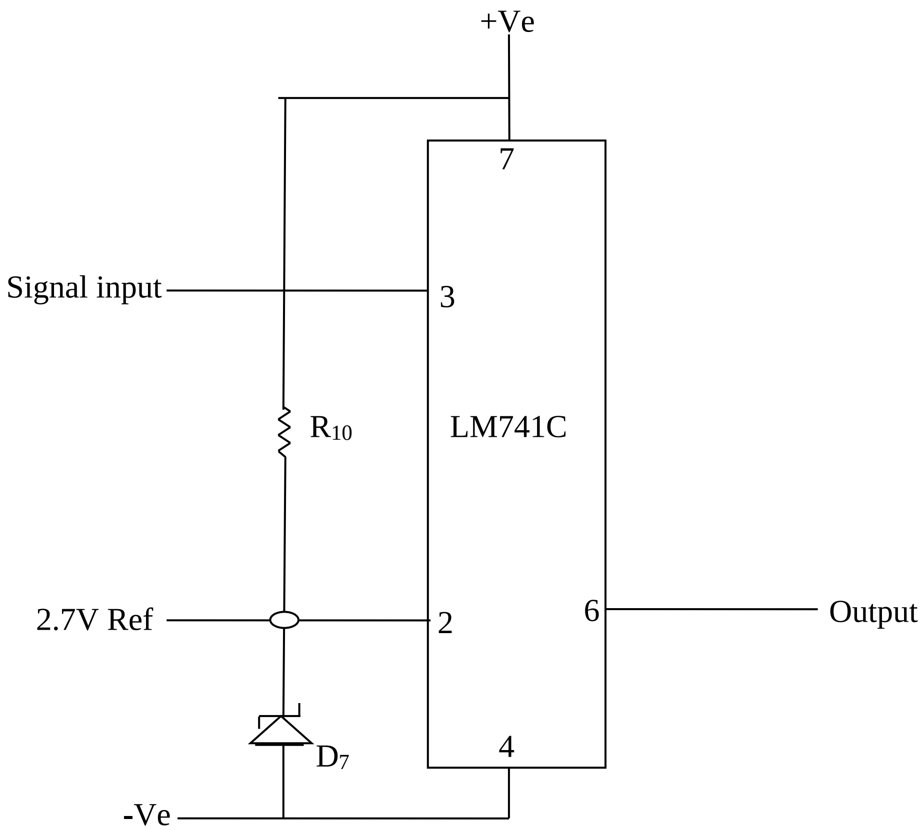

Figure 19. Circuit Diagram of Comparator Unit.

3.4.6. The Output Unit

The output unit is built around a switching transistor Q2 (BD243C) that is biased into saturation once there is positive voltage from the voltage comparator. The biasing voltage is controlled by a fixed resistor R12 to prevent short circuit current into the base region. A DC powered buzzer is connected as load at its collector region. Also, from the output of the comparator,another connected load – the visual indicator. A red LED is used for the visual indication. Again, the current through it is controlled by resistor R11. Both the buzzer and the LED are expected to be activated at the detection of a GSM signal, provided their nearby set being tracked is active. The circuit connections of the output unit and the entire complete design are as shown in figure 20 and 21 respectively.

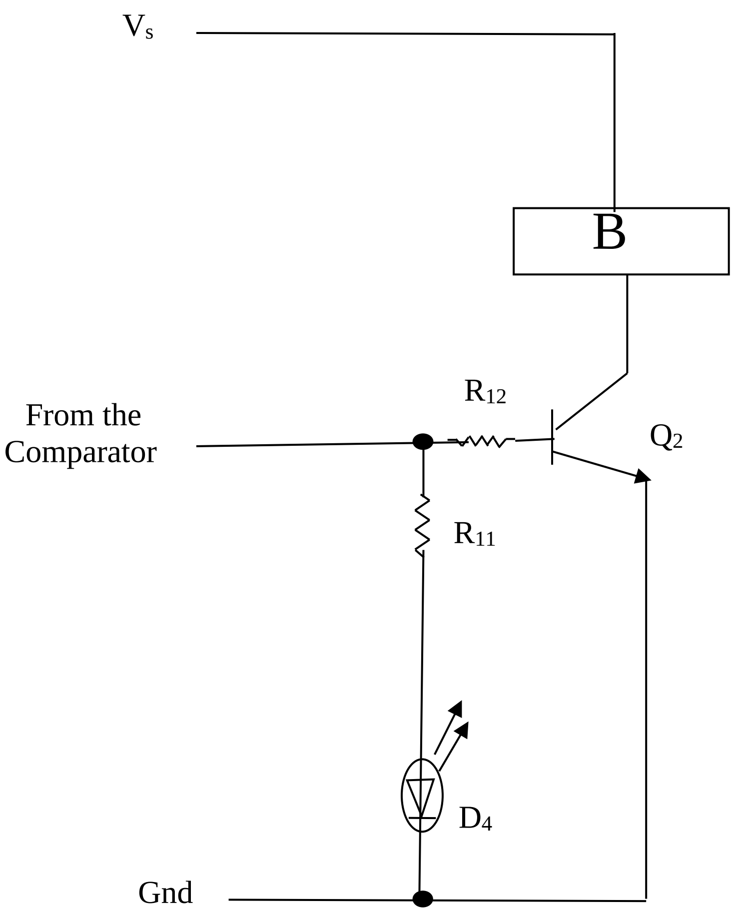

Figure 20. Circuit Diagram of the Output Unit.

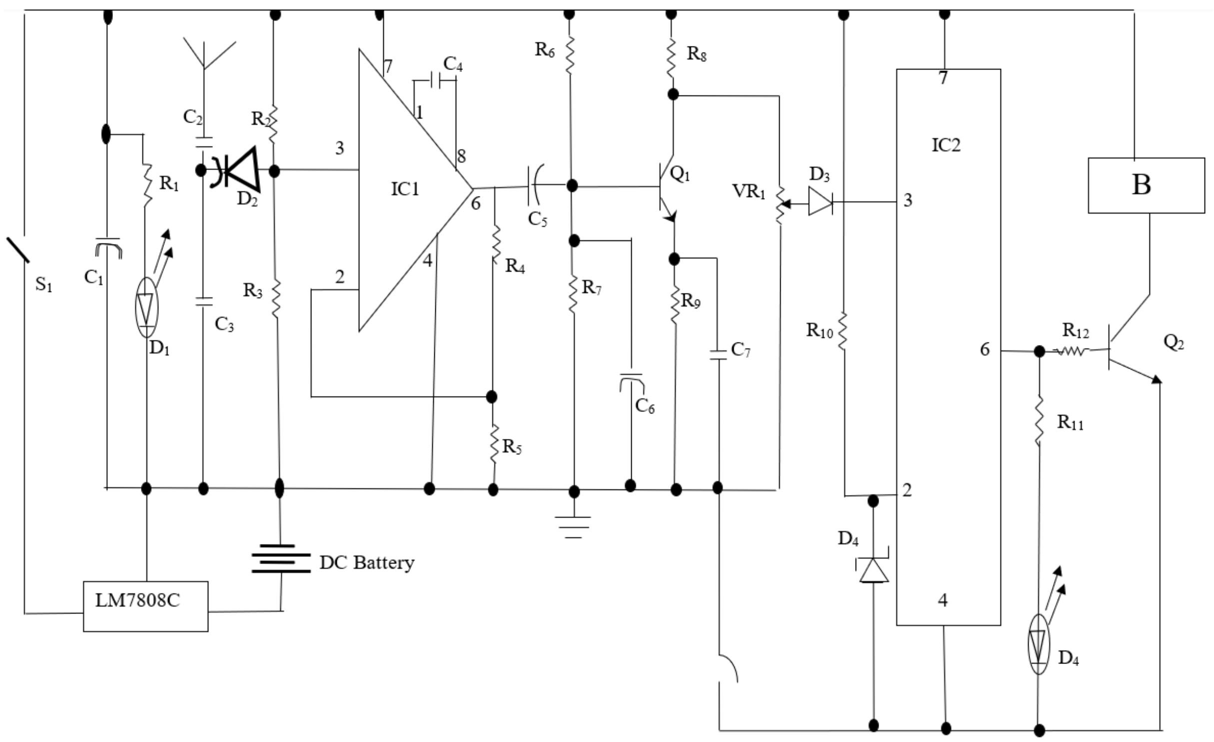

Figure 21. Complete Circuit Diagram of Designed Project.

3.5. Testing and Results

This exercise was carried out, one step after the other, and the results gotten are as contained in the table 2 below

Table 2. Testing and Results Obtained for the Designed Project.

S/N	TESTING PROCEDURES	RESULTS OBTAINED	REMARKS
1.	Power Switch put ON.	The LED for the power indicator came ON	This meant that the circuit has been powered, ready for signal reception.
2.	An active phone was put at a place disguisedly covered. Then a call was made from another phone from a far distance	There was no sign of the hidden phone ringing. But the buzzer got activated, and the LED was fully ON	The arriving signal has been detected by the project device, and immediately generating audio and visual alerts, irrespective of the hidden phone put on silent mode
3.	The project device is kept a little distance from the hidden phone, about one meter. Then another call was made.	The audio and visual alerts did not come ON this time around.	The device circuitry could not detect the arriving frequency signal due to distance placement of the hidden phone
4.	Hidden phone put at Airplane Mode	There was no consistency from the project device in detecting the arriving signals	The device only worked when the phones are active

4. CONCLUSIONS

With the increase and abusive use of technological devices, most of these cell phones are being applied in many wrong ways; like in the examination halls to aid cheating or confidential rooms to sniffer information. Cell Phone Detector should be used at certain places where use of mobile phones is not allowed, like exam hall, temple, offices and theaters. Other prohibited areas include: Petrol pumps, gas station, historical places, religious places, court of laws, examination halls, spying and unauthorized video transmission, military bases, hospitals, theatres, conferences, embassies (Oke A.O, Falohun A.S & Adigun A.A, 2016). As a way of regulating this, a handy, pocket-size mobile phone detector, can be useful in detecting the presence of such hidden but activated mobile cell phone. Upon receiving a transmitted signal, a cell phone detector will trigger a buzzer to produce beep sound, even if the phone is kept on silent mode. The alarm continues beeping till the presence of RF signals dies down (Rajkumar M et al,2017).

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