

Design and Development of a Mobile Phone Signal Detector.

A.A. Ajasa¹; O. Shoewu²; and P.O. Nwamina³

Department of Electronic and Computer Engineering, Faculty of Engineering,
Lagos State University, Epe Campus

E-mail: ajasaaf@yahoo.com¹
engrshoewu@yahoo.com²
segnwams4real@yahoo.com³

ABSTRACT

This work involves the design and development of a digital signal detector which is capable of detecting incoming and outgoing signals from mobile phones. The presence of an activated mobile phone can be detected by this handy, pocket-size mobile signal detector from a distance of one and a half meters, which could be used in preventing the use of mobile phones in examination halls, confidential rooms etc. It is also suitable for detecting the use of mobile phone for spying and unauthorized video transmission. The circuit can detect the incoming and outgoing calls, text messages, and video transmission even if the mobile is kept in the silent mode. The moment the gadget detects Radio Frequency (RF) transmission signal from an activated mobile phone, it starts sounding a beep alarm and the Light Emitting Diode (LED) blinks. The alarm continues until the signal transmission ceases. The circuit is assembled on a general purpose PCB as compact as possible and enclosed in a small box.

(Keywords: signal detection, light emitting diode, operational amplifier, LC circuit, printed circuit board)

INTRODUCTION

In recent years, there has been increasing focus on issues relating to the use of mobile phones in restricted, prohibited, and unauthorized areas. The reason for this increased interest is largely due to disturbance, as well as wrong and inappropriate usage of mobile phones by the owners and users alike. Other areas like churches, mosques, offices, and prisons, just to mention a few, are not left out. There is need for the detection of mobile phone signals in areas like these.

Efforts have been put in place in tackling this issue but they all have their own shortcomings, one of which is the mobile phone jammer. A mobile phone jammer is an instrument used to prevent cellular phones from receiving signals from base stations. When used, the jammer effectively disables cellular phones. These devices can be used in practically any location, but are found primarily in places where a phone call would be particularly disruptive because silence is expected [1, 4]. The shortcoming of such a technology is the inability to make calls especially in cases of emergencies.

However, this mobile signal detector has the feature of receiving and making calls during emergencies, except that the alarm and the LED will keep beeping and blinking respectively.

Mobile phones use RF with a wavelength of 30cm at 872 to 2170 MHz that is, the signal is high frequency with huge energy. When the mobile phone is active, it transmits the signal in the form of sine wave which passes through the space. The encoded audio/video signal contains electromagnetic radiation which is picked up by the receiver in the base station.

LITERATURE REVIEW

The existing technology currently available in the open market utilizes mostly discrete components, and a design approach using a down converter in conjunction with a band pass filter. These technologies are not adequate because they are inaccurate and expensive.

The first signal detection technique, an RF detector using tuned Inductor-Capacitor (LC)

utilizes discrete components which is difficult to implement [3].

They are very affordable to construct, but requires precision tuning. This design when analyzed was found to be inaccurate. The design incorporated tuned LC circuit which is used to detect low frequency radiation in the Amplitude Modulation (AM) and Frequency Modulation (FM) bands. It detects signals in the GHz frequency band used in mobile phones as the transmission frequency of mobile phone ranges from 0.9 to 3 GHz. A capacitor is used to form a part of the LC circuit as C while the lead (coiled wire) of the same forms the L to receive RF signals from the mobile phone. When the mobile phone is activated the RF transmission signal is detected by the detector and starts sounding a beep alarm and the LED blinks [3].

The second technique seems to be accurate but has its own short comings, in addition to being very expensive. The two most popular mobile phone detectors available under this technology are produced by Berkeley Varitronics Systems and mobile Security products.

These companies produce the wolfhound cell phone detector and cell buster, respectively. The Berkeley Varitronics systems Wolfhound cell phone detects Personal Computers (PCs), Code Division Multiple Access (CDMA), Global System for Mobiles (GSM) and cellular bands using the RF signals. It is also capable to directionally find and locate cellular phones that are nearby [5].

The Wolfhound seems to be a great way to detect cellular phones but may just randomly detect mobile phone communications in the area and not necessarily the Phone or device that set it off.

The Cell Buster from mobile security product which provides continuous monitoring for mobile phone and has voice alert that tells the user to shut their phone off if detected.

The Cell Buster only receives and does not transmit, making it great for areas that are sensitive to cellular phone usage. It also detects phones that are in standby mode.

The Cell Buster also seems like it would work wonderfully for keeping people from bringing their phones into restricted areas, however, like the Berkeley Vantronics systems it has its shortcomings as it takes up to 20 minutes to

detect if it is in standby and that the phone needs to be on and its detection could be random transmission in that area.

DESIGN PROCEDURE/ METHODOLOGY

An ordinary RF detector using tuned LC circuits is not suitable for detecting signals in the GHz frequency band used in mobile phones due to the high frequency at which it transmit and huge energy that it gives out.

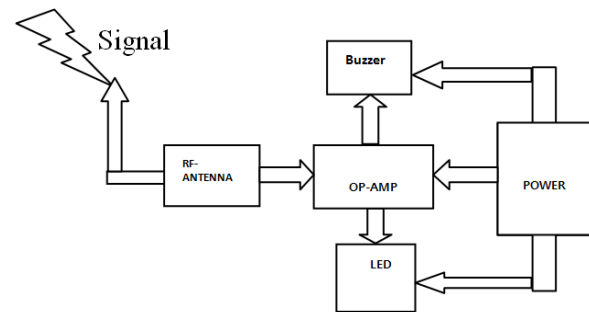


Figure 1: Block Diagram.

The construction of this pocket size mobile phone signal detector is so simple and not expensive. For the construction to be understood and appreciated a more detailed description of the design is required using the block diagram.

The design consists of four stages as shown in the block diagram.

1. The sensor stage
2. The power stage
3. Operational Amplifier (Op-Amp) stage
4. Response stage

From the above block diagram, once the RF antenna receives wireless signal after the circuit has been powered by a 9 Volts dc battery, the operational Amplifier LM358AN amplifies the received signal which is turn triggers the buzzer and makes the LED to flicker when signal is detected.

Principle of Operation

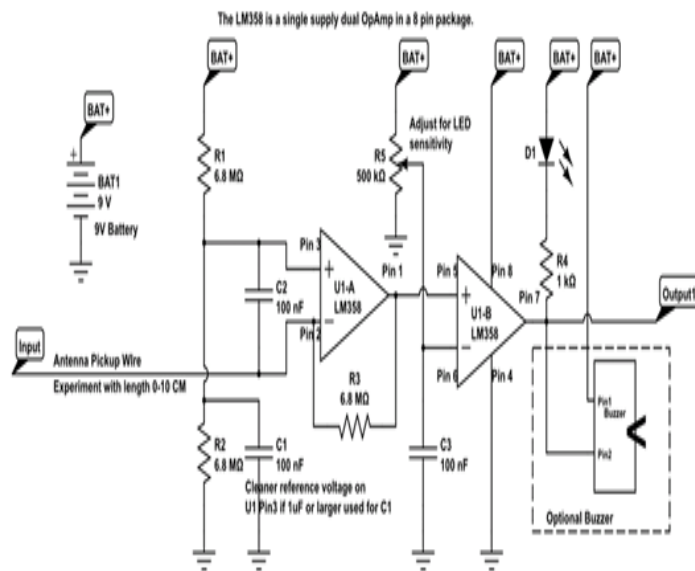


Figure 2: Circuit Diagram.

The transmission frequency of mobile phones ranges from 0.9 to 3 GHz with a wavelength of 3.3 to 10 cm. A circuit detecting gigahertz signals is required for a mobile bug. Here the circuit uses a $0.1\mu\text{F}$ disk capacitor (C2) to capture the RF signals from the mobile phone. The lead length of the capacitor is fixed as 18 mm with a spacing of 8 mm between the leads to get the desired frequency. The disk capacitor along with the leads acts as a small gigahertz loop antenna to collect the RF signals from the mobile phone. Op-amp IC, LM358AN (U1), is used in the circuit as a current-to-voltage converter with capacitor C3 connected between its inverting and non-inverting inputs.

Capacitor C2 in conjunction with the lead inductance acts as a transmission line that intercepts the signals from the mobile phone. This capacitor creates a field, stores energy and transfers the stored energy in the form of minute current to the inputs of U1. This will upset the balanced input of U1 and convert the current into the corresponding output voltage. Capacitor C1 along with high-value resistor R1 keeps the non-inverting input stable for easy swing of the output to high state. Resistor R2 provides the discharge path for capacitor C1. Feedback resistor R3 makes the inverting input high when the output becomes high. Capacitor C3 is connected to R5 and 'null' inputs (pin 6) of U1 for phase

compensation and gain control to optimize the frequency response.

When the cell phone detector signal is detected by C2, the output of U1 becomes high and low alternately according to the frequency of the signal. This makes the LED to flicker through resistor R4 connected to the output pin 7 of the U1, which in turn triggers the buzzer.

CONSTRUCTION

Construction on Bread Board

The construction was first done on a bread board before being transferred on to a PCB. The Op-Amp IC chip (U1) was placed on board straddling the channel. The orientation of the chip was noted after which the variable resistor was then placed with the pins on separate rows.

The center pin of the variable resistor (R5) is connected to pin 6 of the IC, and top and bottom pins to the bottom rows of the board. The bottom two rows are where the battery will be connected. One capacitor (C3) is inserted between the middle and top pins of the variable resistor. Pin 4 of the IC is connected to the bottom left row. Several other locations will use this connection for ground (Negative battery terminal).

A 6.8 Mohms resistor (R2) and a capacitor (C1) is connected between pin 3 and pin 4 of the IC. It should be noted that pin 4 is connected to ground. A capacitor (C2) is then connected between pin 3 and pin 2 of the IC.

A 6.8 Mohms resistor (R1) is connected between pin 3 of the IC and bottom pin of the variable resistor. A wire is needed to make this connection. It should be noted that the bottom pin of the variable resistor will be connected to the battery positive terminal.

A 6.8 ohms (R3) is also connected between pin 1 and pin 2 of the IC.

A wire is used to connect pin 1 and pin 5 of the IC. One leg of the 1Kohms (R4) is connected to pin 7 of the IC. The other leg of the LED is connected to pin 8, and the short leg to the row above pin 8 (the row where one of the 1Kohms resistor leg is connected).

A wire is connected to the bottom right row to the long leg of the LED (pin 8). One end of a long wire (antenna) is connected to pin 2 of the IC. The black wire of the battery is connected to the bottom left of the board while the red wire of the battery is connected to the bottom right row of the board [2].

Construction on a PCB

A printed circuit board (PCB) is a self-contained module of interconnected electronic component found in devices from common beepers, or pagers, and radios to sophisticated radar and computer systems. The circuit is formed by a thin layer of conducting material deposited or printed on the surface of an insulating board known as the substrate. Individual electronic components are placed on the surface of the substrate and soldered to the interconnecting circuit. Figure 3 shows the simulated drawing.

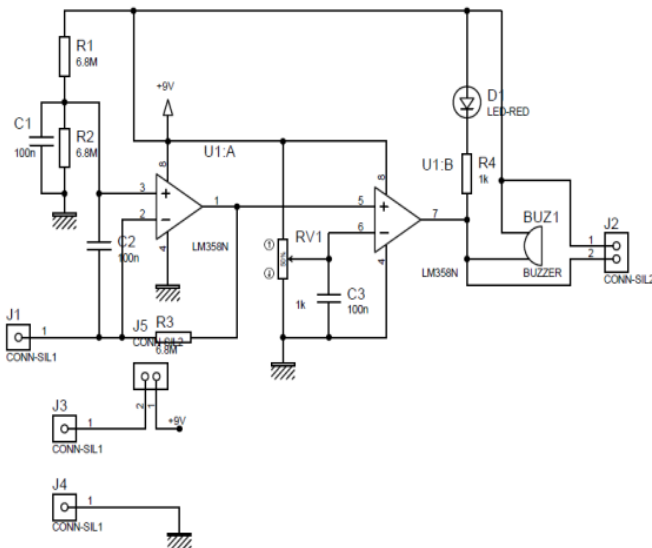


Figure 3: Simulated Drawing.

The design of this circuit is done using PCB123 software and then printed out on a special paper. The software was also used to create the 3D designed circuit and board print as shown in Figure 4 and Figure 5, respectively.

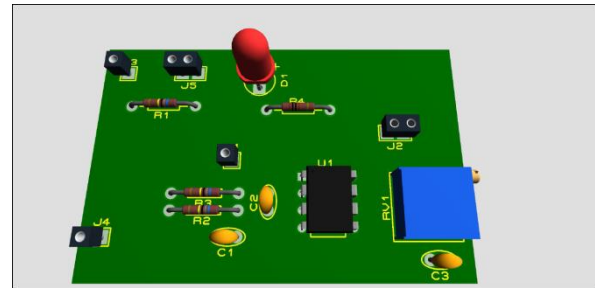


Figure 4: 3D Designed Circuit (Front View).

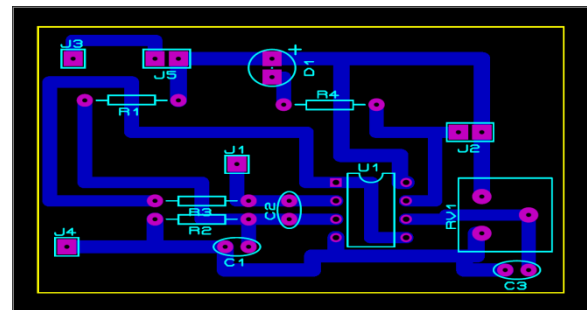


Figure 5: PCB Components and Board Print.

After the print out, the design on this special paper is then ironed onto the board called substrate, which leaves the circuit path on the board.

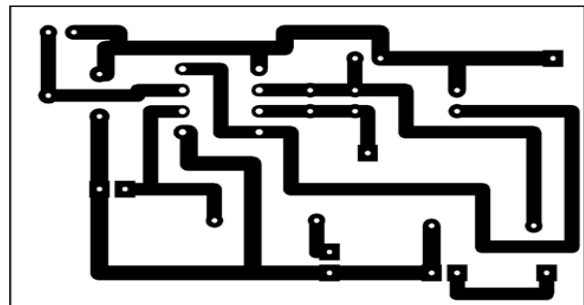


Figure 6: Design Printed on Board.

The substrate is then etched leaving only the conducting circuit path on the board as shown in Figure 6, after this, the electronic components are drilled and the whole board is cleaned and ready for the components to be placed into position. Figure 7 shows the finished circuit.

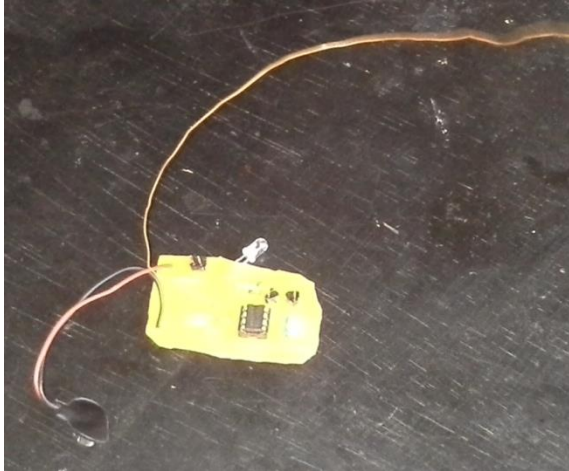


Figure 7: The Finished Circuit.

TESTING AND EXPECTED RESULT

This design was tested in the lab and proven by taking readings of each components before the signal detector detects an active phone and when it does not. Three lab tests were conducted using a spectrum analyzer and signal generator. The finished project was also tested using a mobile phone.

The lab tests were done using a signal generator and spectrum analyzer connected respectively to the input and output using BNC coax cables. The first test was carried out to check if the Op-Amp LM358AN could amplify the received signal, the second test was on how the LED worked in conjunction with the buzzer and the last test was to see how bright and loud the LED and buzzer could be when the circuit receives signal from the signal generator. At the end of these tests, the detector is found to be working as expected with high efficiency.

The components' voltage values were taken using a multimeter and given in Table 1. It could be deduced from the table that there is a constant value for each component when there is no signal or activated mobile phone near the detection range. The reason for this is not farfetched as the battery supplies the voltage, it goes through the circuit across each component. The voltage across the LED and buzzer is not sufficient enough to produce an alert as the rating to produce a sound from the buzzer is 3Volts to 24Volts while that of the LED is 1Volt to 3Volts.

Table 1: Voltage Values across each Component

S/N	COMPONENT	VOLTAGE(V) (when no signal)	VOLTAGE(V) (when there is signal)		
1	Buzzer	1.28	3.5	2.75	1.78
2	LED	0.54	1.9	1.05	0.92
3	C3	2.89	2.61	2.51	1.53
4	C1	3.00	2.75	2.61	2.01
5	C2	0.19	0.15	-	-
6	LM358AN	6.32	5.80	5.72	5.62

When an activated phone is brought in detection range, the voltage across each component either increases or drops. There is a fluctuating voltage drop across the capacitors (C1, C2, and C3) and the Op-Amp LM358AN as the signal is received by the antenna. The fluctuation is due to the irregularity of the signal because it is a sine wave. The voltage across the buzzer fluctuates increasingly between the values of 3.5Volts to 1.78Volts and only comes up with a sharp sound at 3.5Volts but with a faint sound at 2.75Volts and no sound at 1.78Volts. The voltage across the LED also increases and fluctuates as the signal comes and goes, but only come up at a voltage of 1Volt and above.

The moment the bug detects RF transmission signal from an activated mobile phone, it starts sounding a beep alarm and the LED blinks as shown in Figure 8. The alarm continues until the signal transmission ceases. Figure 9 shows the gadget when not receiving any signal.

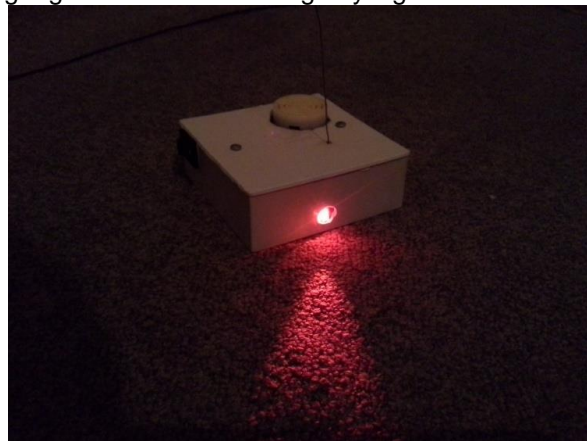


Figure 8: Device when Detecting the Cell Phone Signal.



Figure 9: Device when not Detecting the Cell Phone Signal.

For the mobile test a Nokia mobile phone was turned on and a phone call was placed with the detector nearby. It was noticed that once the call was made and the detector detects the signal, the LED comes up along with the sound but later stops even when the call was not aborted. After much troubleshooting, it was discovered that the wire used for antenna was weak and a better wire was used and the circuit was working effectively and efficiently.

CONCLUSION

Mobile phone technology is gaining new data capabilities very rapidly. Features like Bluetooth, high resolution cameras, memory cards, and internet make them ideal for getting data in and out of secure facilities. A mobile phone uses many different transmission protocols such as FDMA or CDMA. These protocols dictate how Cellular phone communicates with the tower.

Many business and institutions depend on keeping information protected and build fortresses imploring methods like searching everyone entering and exiting which requires a lot of manpower and money.

This portable mobile transmission detector that senses the presence of an activated mobile cell phone from a distance of 1m to 1.5m can be used to prevent instances mentioned above and also the use of mobile phones in examination halls, confidential rooms, just to mention a few.

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