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SYSTEM DESIGN OF CELL PHONE DETECTOR

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Abstract: Cell phones are widely used in the world. While people have to be connected to one another, there are situations or places where there usage is to be prohibited either due to security reasons or it may cause health hazards. Cell phone detection has been on investigation for a long time. There are techniques which have been formulated or proposed on how cell phones can be detected. Most of them use the features such as audio system, radio frequency (RF) system and common materials of the phones and try to look into how they can be used as basis to detect mobile phones. This paper utilizes the RF system of the cell phone as the feature to be used to detect its presence. A circuit that detects signals of the range 0.9GHz to 3GHz is used to detect a cell phone when in use. When the signal is detected, a light emitting diode (LED) blinks to indicate the usage of a cell phone within a radius of 1.5metres.
Keywords: design; implementation; cell phone detector

INTRODUCTION

Cell phones have become an integral part of people's lives. They are not only used for communication via short messaging service (SMS), calls, emails and internet but advanced applications such as remote health monitoring systems and security systems have been integrated with mobile phones[1,2].

The recent years have seen rapid advancements in the value of addition applications in mobile phones such as high definition cameras and high speed internet connectivity. Despite the advantages enjoyed by these advancements in mobile technology, there are threats that have been posed by their usage. Company data mining has been a big threat in the industry where employees are able to access sensitive company information and share with the competitors. This led to the development of cell phone jammers where signal reception is completely blocked when you enter the premises. Despite personal privacy invaded by the usage of such devices, this could not put to end the vice since mobile phones could be connected to the computer and information transferred and sent when the employee is out of the company premises. Criminal activities and attempted escape incidences have been organized by inmates in correctional institutions through the use of mobile phones in such facilities. The most common incidence is when people were conned by inmates who impersonated promoters and required winners to send money as fees to facilitate the award of prizes. Life support machines are also sensitive to the use of mobile phones. 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. Other places are aeroplanes, petrol stations, conference halls, examination halls, worship centers, etc., where the use of mobile phones can either lead to failure of sensitive machines or is a nuisance[3,4,5].

It is therefore a reality that mobile usage in some places must be prohibited. Due to the privacy laws that limit the use of cell phone jammers, cell phone detectors must be designed and installed so that in case a person gets in with a phone into such places, they can be notified and either told to switch them off or take them outside. The effectiveness of cell phone detectors is that they continually scan for the presence and usage of the cell phone and sound an alarm to notify the user or security personnel [6].

DESIGN METHODOLOGY

Among the detection techniques, the RF spectrum approach is selected for implementation. The choice of this selection is based on the ease of implementation due to readily availability of the discrete components required in the local market. The block diagram of the design is shown in Figure1 below. Based on the block diagram of Figure1, the circuit design of each block is designed and the final circuit integrated together. The subsequent sections explain the detail and design of each block diagram.

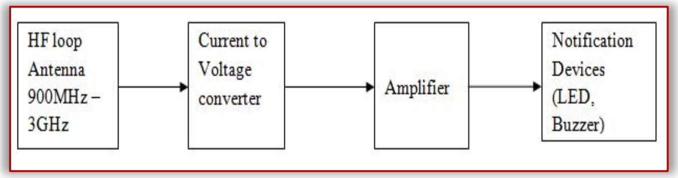

Figure 1. Block diagram

— High frequency loop antenna

The frequency to be detected is 0.9 Gigahertz to 3 Gigahertz. Passive components suffer from parasitic effects at this high frequency. In ordinary radio frequency antenna design, LC components tuned at desired frequency are used. However, at this frequency the components behave as lumped R, L and C and as transmission lines and antenna. In the loop antenna design at this frequency, the parasitic effects of these elements are used.

The loop antenna consists of a 0.22uF ceramic capacitor with it leads fixed at 18mm long and 8mm wide. These dimensions provide an area sufficient to capture the frequency required. Hence, it is a loop antenna. When there is no signal detected, the capacitor charges and stores energy. When a field created by the presence of a mobile phone is detected, the energy balance in the capacitor is perturbed. A displacement current is injected into the capacitor leads generating a magnetic field hence inductance in the leads. The inductance together with the capacitance acts as a transmission line that transmits the current to the current to voltage converter.

— Current to voltage converter

The current to voltage converter shown in Figure2 consists of a CA3130E operational amplifier. It has a MOSFET input stage and a CMOS output stage. The input stage provides a very high input impedance and low input current (typical 5pA at 15V). Since the loop antenna generates very small current, this makes this type of operational amplifier suitable for this application. Furthermore, it is a single power supply operational amplifier. Therefore, it gives no hard work generating a negative biasing voltage as a dual voltage operational amplifier. The CMOS stage provides an output swing to about 10mV of the supply voltage.

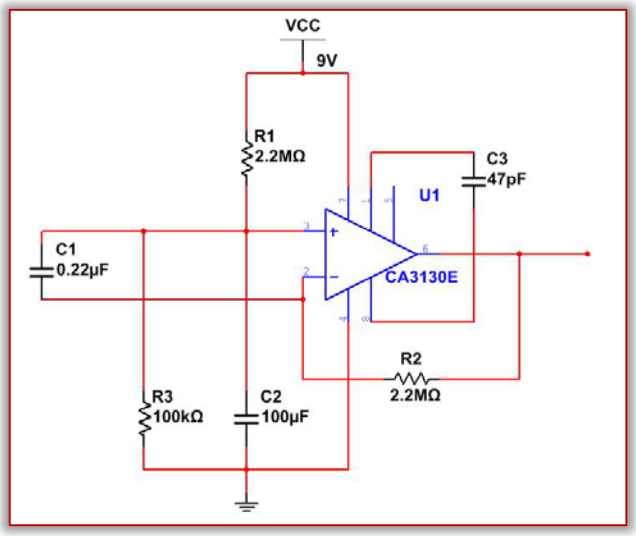

Figure 2. Current to voltage converter

The operational amplifier is connected as a current to voltage converter and has a voltage comparator. The comparator consists of R1 and R3 connected on the non-inverting terminal. These two resistors responsible for setting V_{ref} at 0.52V using voltage divider formula.

From Figure 2, the 0.22µF capacitor which acts as a loop antenna is connected across the non-inverting and inverting terminals of the operational amplifier. The capacitor stores energy and in the absence of a mobile phone, both the positive and negative terminals receive the same voltage, that is equal to V_{ref}, hence the output of the operational amplifier is low.

When a mobile phone is radiating and its frequency is sensed by capacitor C1, the balance between the inverting and non-inverting terminals of the operational amplifier is perturbed. The current is transmitted to the non-inverting terminal and a voltage is sensed at the output. The 100uF electrolytic capacitor (C2) connected to the non-inverting terminal ensures stability of the terminal and fast output swing. The capacitor charges during operation and to bring it back to stable condition, the 100K resistor (R3) provides a discharge path.

The feedback resistor is not for amplification but provides feedback to the inverting terminal such that when the output goes high, the state is also fed back to the inverting terminal making it high. However, since the frequency of the radiation from the mobile phone is pulsating, the sensing capacitor C1 (loop) oscillates hence the output.

— Amplifier

Since the voltage at the output is small, it needs to be amplified in order to drive the notification devices (LED or sound buzzer). At standby mode of the cell phone, the voltage output from the current to voltage converter can be as low as 10mV. Therefore an amplifier that has little or no offsets voltage level is required. The best amplifier is a two stage transistor based as shown in Figure3. An op-amp based would suffer from offset voltages hence not effective in this design. With a low voltage of this order, it is hard to eliminate the effects of noise due to the sensitive tuning of the amplifier.

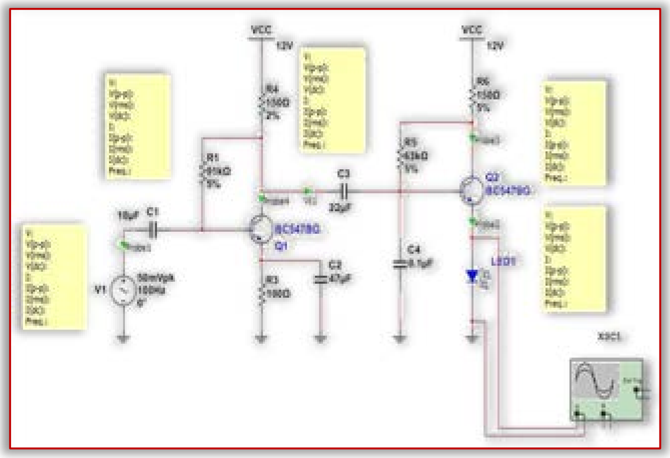

Figure 3. Amplifier

The 10µF input coupling capacitor blocks any dc voltages at the input. The biasing used is the collector-feedback bias. The advantage of this bias design in RF operation is that it provides temperature stabilization such that as the temperature increases, the transistor starts to conduct more current from emitter to collector.

Since the base resistor is directly connected to the collector, any rise in collector current (Ic) will permit more voltage to drop across the collector resistor. This will force less voltage to be dropped across the base resistor hence base current (I_B) decreases and consequently Ic.

The bypass capacitor at the emitter bypasses the RF signal around the emitter resistor to avoid excessive RF gain degeneration in the circuit.

C4 (0.1µF) is connected between the base and emitter of the transistor in the final stage to ensure that it provides fast switching of the transistor.

The final stage which is the notification stage is integrated with the amplifier. The chosen notification in the design is an LED. The LED is connected to the emitter of the last transistor of the final amplification stage. The operating point of the voltage at the emitter is held at about 3.0V to ensure that a small variation of the voltage due to voltage swing from the current to voltage converter would make the LED to blink.

— **Complete circuit**

The complete circuit for the cell phone detector is shown in Figure 4. The 22pF capacitors are connected to the antenna side. The antenna is to make sure the detector receives the optimum level of the signal from the phone.

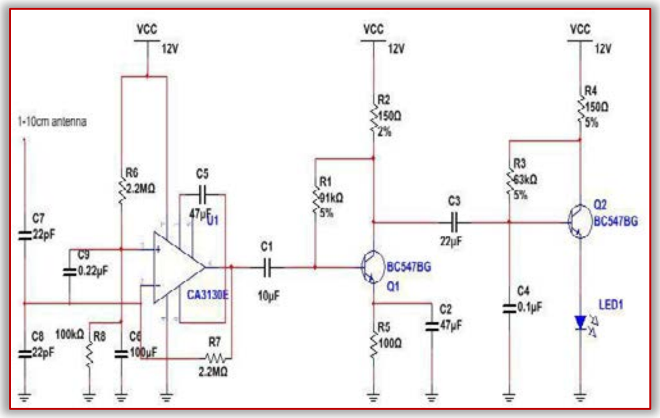

Figure 4. Complete detector circuit

RESULTS

— **Simulation results**

The loop antenna designed in this paper is not subjected to simulation environment due to the limitation of the software at the design operating frequency of the detector. Most soft-wares are limited to 100MHz operating frequency. Beyond this point, the software overloads the central process unit(CPU) hence no real time results can be obtained. Furthermore, at the very high frequency operation expected, the parasitic effects of the passive elements will not be depicted in the software environment hence real-time operation of the detector could not be obtained by simulation.

The amplifier is simulated, in place of the current to voltage converter, a signal generator is used. The amplifier is simulated at 50mV pk voltage and the voltage waveforms at the LED monitored.

With the swinging of the voltage at the output, the LED is found to be blinking. Therefore it is expected that upon connection of the detector and current to voltage converter to the amplification stage, the LED would blink as expected in these simulation results as shown in Figure 5.

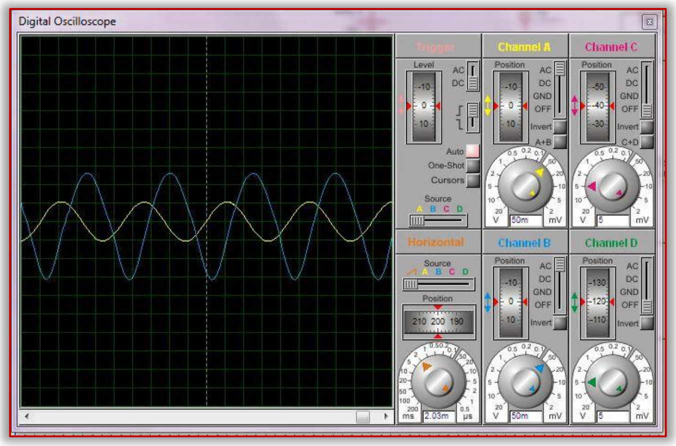

Figure 5. Output simulation results

— **Practical results**

The practical results obtained from the detector before and after a cell phone is adjacent to the detector are shown in Figure 6 and Figure 7. Figure 6 shows the detector output when cell phone is not in use, while, Figure 7 shows the detector output when cell phone is in use.

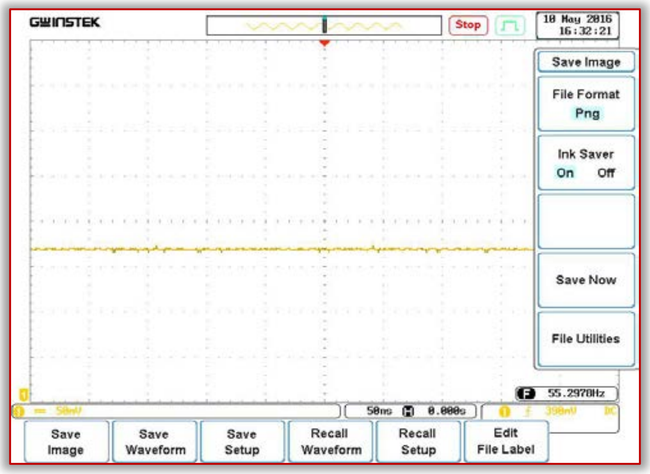

Figure 6. Detector output when cell phone is not in use

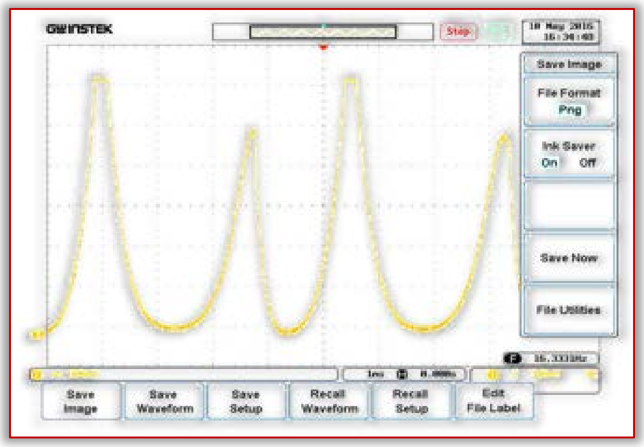

Figure 7. Detector output when cell phone is in use

At the output of the cell phone detector circuit, an LED is used. The practical waveform obtained is shown in Figure8. This output waveform makes the LED to blink indicating that a cell phone is in use.

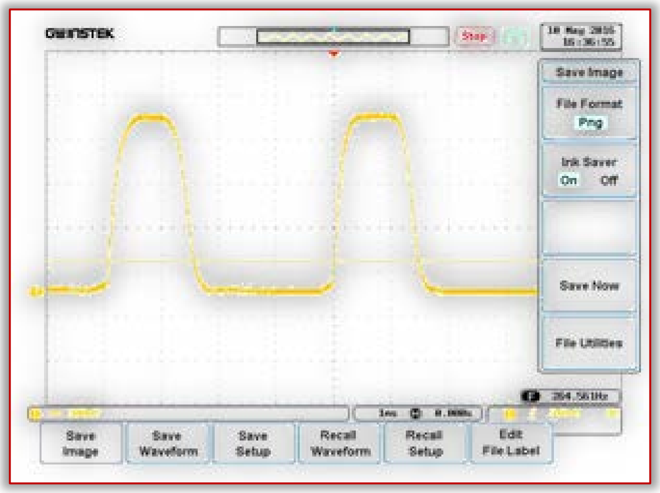

Figure 8. Output of LED

Upon completion, the user is allowed to install new devices in the system. This includes bedroom light, sitting room light, A DVD player radio system and a gate. Each of these devices are then assigned operating commands shown in the command table 1. When the system is fully initialized, the user exited graphics thereafter activating speech operating mode for the system as shown in Figure 8.

CONCLUSIONS

The results in this paper show that the cell phone detector worked sufficiently. The detector could detect the signal in the frequency range of 0.9GHz to 3.0 GHz, thus a cell phone that is in use. This phone usage was indicated by the blinking of the LED. When a cell phone is on standby mode, it keeps a radio silence therefore cannot be detected using this cell phone detector. This detector can therefore be used to track the usage of a cell phone in an examination room where a buzzer usage will be too loud and disturb the examiners.

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