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(RESEARCH ARTICLE)

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Design and construction of cellular phone calling detector

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Abstract

Cellular phone detector is an electronic device that when placed some few centimeters away from a mobile phone pulse-blink by a way of lighting a light emitting diode (LED) whenever a call is made to the phone. The ability of the detector to successfully indicate a light on the LED is highly dependent on the distance between the phone and the detector. Accordingly, there is need to improve the distance of separation. The aim of this research project is to design and construct a device that when placed a few centimeters away from a phone lights up a light emitting diode (LED). The signal detected is enabled by a coil used as an antenna which receives signal and then amplified by a transistor which drives the monostable input pin of the IC 555 timer. Thus, a light emitting diode lights up indicating a call made to a phone. This research discovers that as the number of turns of the coil increases and the calling detector is placed far from the phone, the weaker the signal becomes. Future studies will focus on increasing the distance of the separation to any length that is convenient for use.

Keywords: IC 555 timer; Antenna; Light emitting diode; Pulse-blink; Detector; Coil

1. Introduction

Mobile phones emit small amount of electromagnetic signals through the radio waves which is radio frequency energy. Every mobile phone has a low power transmitter in them. While talking over the cell phone, the transmitter takes the sound of voice and changes it into a continuous sine wave. Since wave is measured in terms of frequency [2]. Transmitter sends the sine wave to antenna. Antenna transmits the sine wave in the form of electromagnetic signal to the Base Transceiver Station (BTS). Cell phone works by communication between service networks through base transceiver station or cell tower. Cell tower divide the city into small areas or cells. As the user moves from one cell to another, the signal along with the information is handed over from tower to tower [5].

Electromagnetic radiation (EMR) is at the heart of modern mobile phone data communications networks. The way a mobile phone and local base stations communicate between each other is by using Electromagnetic radiation in the radio wave part of the spectrum. On switch–on your mobile sends digital information pulses by rapidly switching on and off the radio waves rather like a fast Morse code signal. Your text of voice is also converted into a series of digital pulses and sent a cross the network to be decoded (reassembled) by another mobile phone you dialed [4].

It is commonly seen that we people forget where we placed our cell phones; this habit will be a cause for losing it, when the phone is in silent mode. Some of us thought of solving the problem with the help of an electronic circuit and we are able to set up a circuit that enables us to locate the phone even if it's in silent mode.

Described is a simple low cost home – made device that converts the radio wave energy from a mobile phone signal into electricity to light emitting diode (LED).

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1.1. Related Works

There are some researches on mobile phone calling detector. [3] discovered that cell phone calling detector could detect incoming signal in the frequency range of 0.9GHz to 3.0GHz by the blinking of the LED however failed to account for the distance within which such a detector must be kept away from the mobile phone. [5] worked with a resistor-capacitor circuit and found a range of 1.0m for the phone calling detector. This was able to detect incoming/outgoing calls as well as text messages and video transmission. But due to the limitations of the circuit, the distance of the detector was greatly affected.

2. Material and methods

This section takes us across the preliminary design which includes the input unit, processing unit and output unit and the materials used for construction. Furthermore, we will consider the overall circuit diagram, circuit analysis, circuit description and the function of the circuit.

2.1. Materials used for the Construction

Below is a table showing the various components used in constructing a cellular phone calling detector. The table consists of three columns that describe the components, units and specification:

Table 1 Materials used for construction

Components	Units	Specification
Resistor	1	100KΩ
Resistor	1	3K9Ω
Resistor	1	1MΩ
C1	1	100nF 63V polyester capacitor
C2	1	100nF 63V polyester capacitor
C3	1	220μf 25V electrolytic capacitor
D1	1	LED Red 10mm ultra-bright
D2	1	IN5819 40V IA Schottky-barrier Diode
Q1	1	BC547 45V 100MA NPN transistor
IC1	1	Ts555CN CMr5 Timer IC
L1	1	Sensor coil of 130-150 turns
B1	1	9V Battery

2.2. Circuit Design

The design describes basically the three sections of the project. These sections were actually done on a bread board to test-run the project before they were transferred to the perfect board. These sections include the input unit, processing unit and the output unit. Due to the miniaturize nature of the project, the design was based on these units.

Table 2 Block diagram of the sections of the circuit

Input unit	Processing Unit	Output Unit

2.3. Input Unit

Power is the ultimate source of every electronic device. Power in an electric circuit is the rate of flow of energy past a given point of the circuit. In alternating current circuits, energy storage elements such as capacitors may result in periodic reversals of the direction of energy flow.

In a simple alternating current (AC) circuit consisting of a source and a linear load, both the current and voltage are sinusoidal. If the load is purely resistive, the two quantities reverse their polarity at the same time. At every instant the product of voltage and current is positive, indicating that the direction of energy flow does not reverse. In this case, only real power is transferred. If the loads are purely reactive, them the voltage and current are go degrees out of phase. For half of each cycle, the product of voltage and current is positive, but on the other half of the cycle, the product is negative, indicating that on average, exactly as much energy flows toward the load as flows back. There is no net energy flow over one cycle. In this case, only reactive energy flows-there is no net transfer of energy to the load.

However, in the design of this project the D.C. power was chosen over the A.C. power because of the following reasons:

- Reactance: D.C. power (direct current power) does not introduce a reactance in the line. This translates to higher power transfer capability of the line (since only real power is transmitted) and higher capacity utilization of the generators. Voltage drop will also be reduced along the transmission line.
- Frequency: In D.C. system, the frequency is zero, thus, no frequency variation to monitor. D.C. generator connection to the transmission grid will not any more require synchronization procedures.
- Cost-effective: Also, D.C. power is very economical in the sense that the price from its benefits is higher than the cost incurred from the addition of extra equipment - Rectifier and converter.

Therefore, for this design, the D.C. power of D.V. was used. Other components of the input section include:

- Sensor coil (l1)
- Resistor (R1)
- Capacitor (C1)
- Transistor (Q1)

The components formed the preamplifier of the circuit. The preamplifier (preamp) is an electronic amplifier that prepares a small electrical signal for further processing. A preamplifier is often placed closer to the sensor to reduce the effects of noise and interference. It is used to boost the signal strength to drive the cable to the main instrument without significantly degrading the signal-to-noise ratio (SNR). In general, the function of a preamplifier is to amplify a low-level signal to line-level.

Recalled from the transistor rating of BC547,

Collector current continuous
---0.3mA---10mA
Collector emitter voltage Vced
----40V---45V
Collector Emitter Voltage Vces
---45V---50V
Base Emitter saturation voltage VBE (sat)
---0.5μA---5MA
HFE 110---800

From here, the values of the resistors (R1 and R2) can be calculated as follows;

When the transistor is fully turned ON, the current flowing should be at least close to maximum current.

IcMax = Vsupply/R1 hence R1 = Vsupply/IcMax

Let IcMax = 2.4Ma therefore

R2 = 9.0V/2.4mA=3,750Ω =3.75KΩ approx... =3.9kΩ

Calculating the value of R1 as a rule of the thumb, the current through R1 must be at least eleven (11) times the required base current, so that changes in base current will not affect the voltage drop across R1 significantly, if the Hfe used is 400, the standing collector current must be known (this is the value of the current that will flow in the collector before an a.c signal is applied). That is, Hfe=Ic/Ib so that Ib=Ic/Hfe =0.36mA/400 = 0.9µA

Therefore the current flowing in R1= 11 x Ib= 0.99µA

The voltage across R1 is the supply voltage less than the base bias voltage (8110mu) and the emitter voltage Ve.

VR1 = 9-8.11 = 0.89V

Therefore, R1 = 0.89V/0.99µA =898KΩ approx. =1000KΩ

The sensor coil receives signal from the incoming call on the mobile phone or the cellular phone and then the signal so receives is then amplified by the transistor Q1 which drives the monostable input pin of the I.C. 555 timer. Below is a diagram of the input unit.

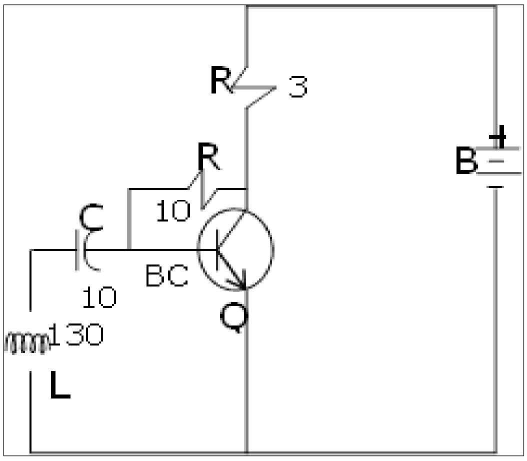

Figure 1 Circuit Diagram for Input Unit

2.4. Processing Unit

Below is a table showing the various pins and their purpose on the circuit:

Table 3 Pins and their Purpose on the Circuit

Pin	Name	Purpose
1	GND	Ground, Low level (OV)
2	TRIG	OUT rises, and interval starts, when this input falls below 1/3 Vcc.
3	OUT	This output is driven to approximately 1.7V below +Vcc or GND.
4	RESET	A timing interval may be reset by driving this input to GND, but the timing does not begin again until RESET rises above approximately 0.7 volts. Overrides TRIG which overrides THR.
5	CTRL	“Control” access to the interval voltage divider (by default, 2/3 Vcc).
6	THR	The interval ends when the voltage at THR is greater than at CTRL.
7	DLS	Open collector output; may discharge a capacitor between intervals. In phase with output.
8	V+, Vcc	Positive supply voltage is usually between 3 and 15V.

Note: Pin 5 is also called control voltage pin. By applying a voltage to the CONTROL VOLTAGE input, pin 5, you can alter the timing characteristics of the device.

This Unit of the design acts as the manipulating unit of the detector. Here, the amplified signal by transistor Q1 is what is used to drive the monostable input pin of IC1.

In this IC1, the CONTROL VOLTAGE input was not used.

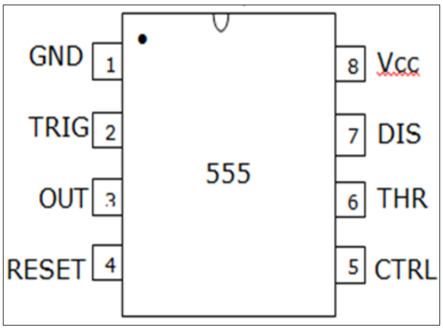

Figure 2 IC 555 Timer showing its Pins Arrangement

2.5. Output section

This is the final stage of the design of the circuit. The output voltage from PIN 3 of the 555 timer IC is double by C2 and D3 in order to drive the light emitting diode (LED) at a suitable peak – voltage.

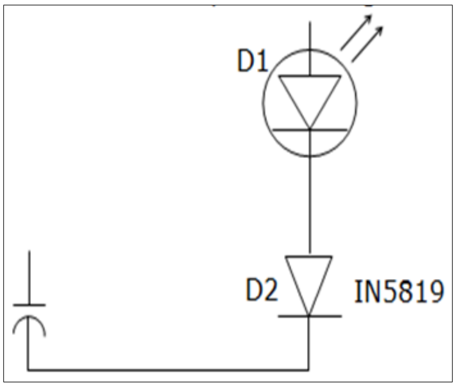

Figure 3 Circuit diagram for output unit

2.6. Overall Circuit Diagram

Below is the complete diagram of a cellular phone calling detector:

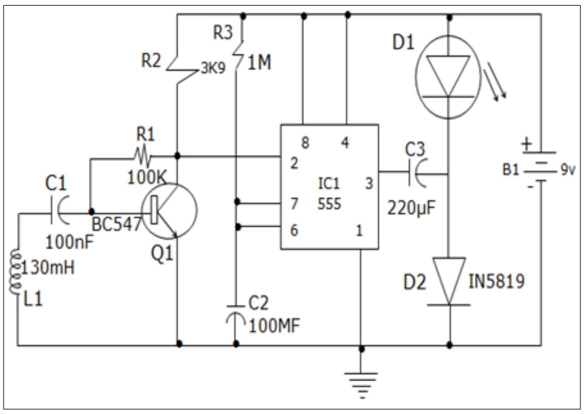

Figure 4 Overall Circuit Diagram

2.7. Circuit Analysis

When a radio wave passes across a metal object, the electromagnetic fields causes the charged electrons in the metal to oscillate and this causes small alternating current (a.c.) at the same frequency to be induced into the metal. If a mobile phone is brought near to the circuit and a call or text is made, the ratio wave emitted from the phone passes across the circuits. This induces a voltage into the antenna (the coil) and thus light up the light emitting divide (LED). When a call is coming to the mobile phone, the transmitter inside it becomes activated. The coil L1 picks up these oscillations by induction and feds it to the base of Q1. This makes the transistor Q1 activated. Since the collector of Q1 is connected to the pin 2 of I.C.1, the I.C.1 is triggered to makes the LED connected at its output pin (pin 3) to blink, the blinking of the LED is the indication of incoming call. The electric and magnetic fields making up the electromagnetic wave are orthogonal (they are at right angles to each other as they pass through space) to each other but depending how they are generated by the transmitting antenna can arrange themselves in any orientation with respect to the ground. If the electric field is parallel with the ground, we say the wave is “horizontally polarized” while if it’s normal to the ground we say its “vertically polarized”.

The loop antenna will respond best to one type of polarization (depending on its orientation) so it’s worth experimenting with the orientation of the mobile, (or the loop) to get the strongest signal-brightest LED. Capacitor C3 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 stores energy in the form of minute current to the input of IC1. This will upset the balanced input of IC1 and convert the current into the corresponding output voltage.

2.8. Circuit Description

The receiver coil L1 detects the signal and the detected signal is amplified by transistor Q1 and drives the monostable input pin of IC1. The IC’S output voltage is doubled by C2 and D2 in order to drive the LED1 at a suitable peak-voltage. Stand-by current drawing is less than 200μA. sensitivity of this circuit depends on the sensor coil type. L1 can be made by winding 130 to 150 turns of 0.2mm enameled wire on a 5cm diameter former.

The coil is then removed from the former and wind with an insulating tape, thus obtaining a stand-alone coil. Transistor Q1 is responsible for flipping the trigger pin on the 555 timer (pin 2). The transistor does the flipping when the pickup circuit comprising of L1 and C1 receives a signal from the cell phone.

2.9. Function of the Circuit

The ultimate function of this circuit is to detect an incoming call made to a cellular placed some few centimeters away from the circuit. This detection is made by a pulse blinking of the light emitting diode (LED).

3. Conclusion

This research has shown that whenever a call is made to a phone that is placed some few centimeters away from a detector, the detector pulse – blink from a detector, the light emitting diode (LED).The result of this research project support the idea that phone calling detectors be placed in banks, classrooms, work places etc. This research work has gone some way towards enhancing our understanding of the need for phone calling detectors and this paving way for more research works to be carried out on this field. The most important limitation lies in the fact that the distance of separation between the phone and the detector is very small. More broadly, research is also needed to determine greater distance of separation between the detector and the cellular phone. There is therefore, a definite need for Government and other stakeholders involved in the various sectors of the economy to fully activate or implement phone calling detectors in places of work as this will go a long way in increasing efficiency and boosting of man-power.

Recommendations

Due to the small distance of separation (2.0m) between the cellular phone calling detector and the mobile phone, the following recommendations can be implemented to solve the problem:

- You can play around the coil L1 to see if you can create a more sensitive pick – up. Try rotating the plane of the coil (vertical/horizontal) when it rest on the table.
- You can also try to see if you can increase the number of turns.
- The bias current in the transistor should be placed closer to the trigger point meaning that an even weaker signal should still do the triggering.

Therefore, it is expected that if the above recommendations are made, the distance of separation between the detector and the phone will not be a problem.

Compliance with ethical standards

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Disclosure of conflict of interest

Paul Erungworo Okayim and Engr. Anthony Aluamaka declare that they have no conflict of interest.

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