Design of a Prototype to Detect Mobile Phone Usage in Restricted Areas

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Abstract
Mobile phones are a great tool developed in the field of information technology. The fast access to information along with the ability to communicate globally is what makes it a boon to people. But in some areas like classrooms, examination halls, petrol pumps or in an aircraft it has become a menace. As a result it is necessary to implement strict measures and to follow the rules regarding the use of mobile phones in such areas.
In this paper a system is proposed which can be used to detect mobile phone usage in mobilerestricted areas. The problem statement was formulated using Labview software and prototype was designed to detect the usage of mobile phones, give warning messages and report about the usage to the concerned authority.

Keywords—*Control unit, Labview, Mobile phone, Remote unit, RF detector, Wireless transmitter and receiver.*

I. INTRODUCTION

The mobile phone has revolutionized the field of communication. It has brought the world closer and has made even live talk possible across any part of the world. With the boom in mobile technology, the coverage has improved diversely, leading to network presence almost everywhere. But in sensitive areas like a classified office, examination halls or in an aircraft it has become a menace. Hence, implementation of strict measures is required to curb its usage in these areas[1,2].

The paper discusses the detection of mobile phones used in no mobile zones, ironically due to presence of network in the area. It will help in better implementation of rules regarding the non-usage of mobile phones in educational institutions, offices and other restricted areas. The paper primarily deals with the development of a prototype that is able to detect mobile activity in these zones and alert the concerned authority. The secondary objective was to develop the above system with minimal cost, hence it can be implemented commercially.

The block diagram and working of the system is discussed in Section 2. Section 3 discusses the formulation of the system using Labview. Prototype implementation is described in Section4. The results obtained after the system was designed are shown in section 5. Then the conclusion is presented at the end of the paper.

II. SYSTEM BLOCK DIAGRAM

The block diagram of the designed system is shown in Figure1. It mainly consists of two units namely: Remote unit and Control unit.Following this, the chassis for the project is designed, keeping in mind, the placement of all the components used in the final prototype. Once this is accomplished, the system is made more user-friendly by covering the outside, while allowing room for the sensors alone.

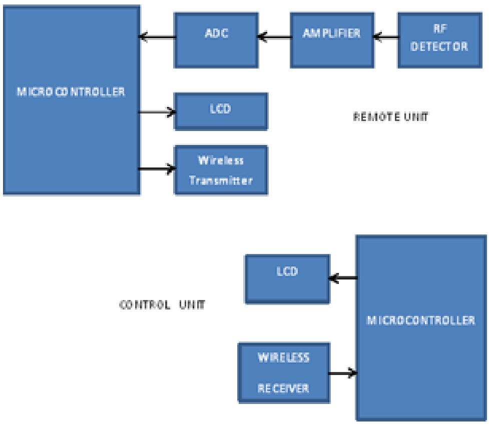

Fig1: Block Diagram of the Proposed System.

Remote unit - The remote unit is a part of the system which is placed in the mobile restricted area. The remote unit detects the use of mobile phone and if affirmative then displays a message to acknowledge the usage. The unit does so by detecting the R.F. (Radio Frequency) signals generated by the mobile phone in case it is being used. The remote unit consists of the following blocks-

- R.F. detector unit
- Amplifier
- ADC
- Microcontroller
- LCD
- Wireless Transmitter

Control Unit - The control unit is placed in the security room. The usage of mobile phone is alerted to the concerned authority. The control unit receives the message regarding the location of mobile phone being used which is relayed by the remote unit. The control unit consists of the following:

- Wireless Receiver
- Microcontroller
- LCD

The flowchart which explains the working of the proposed system is shown in Figure2.

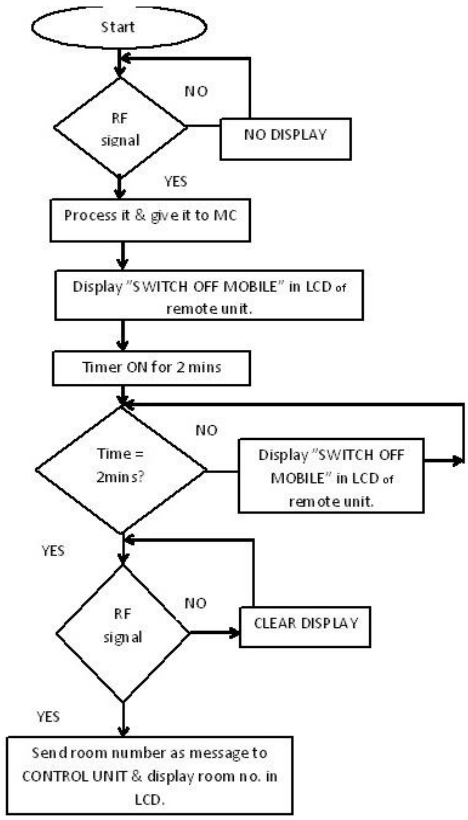

Fig2: Flowchart Depicting Working of the Proposed System.

The working of the proposed system is described in three steps as follows:

Detection of mobile signals

The first two blocks of the remote unit i.e. R.F. detector, and amplifier together are the detection module of the system. For the detection of radio frequency signals generated by mobile phones, a R.F. detector unit is used which is designed for 900 MHZ with the tolerance of 50 MHZ[3].The detected signal is given to the amplifier because, for proper measurement and further processing, the signal with good strength is required.

The processing of the detected signal is done using microcontroller. The microcontroller understands binary and works on digital format hence an ADC unit is needed to convert the detected signal into a digital form. Then depending on the data present in the port of the microcontroller, it then displays a predefined message on the L.C.D. The data other than '00h' indicates presence of RF signal.

Relay to control unit

The wireless transmitter and the wireless receiver together are responsible to get the message to the control unit. The wireless transmitter is in the remote unit whereas the wireless receiver is in the control unit. If the signal is detected continuously for a certain period of time then the information about usage of mobile phone in the respective area is transmitted to the control unit.

The coordination between the remote and the control unit is vital for the successful working of the proposed system.

III.LAB VIEW

Lab View is an acronym for Laboratory Virtual Instrumentation Engineering Workbench. It is a software that helps in development of instruments, simulated to give real world results. The software contains two parts. Like any scientific instruments it consists of a front panel, which has the control knobs and the screen to view the outputs. The second part is the block diagram. This is the internal setup of instruments. The software contains various blocks or modules of functions (mathematical, signal processing etc.) which are pre-programmed to perform a particular task (add, filter etc.). The advantage of using Lab View is the simplicity and the ease of use. The various blocks can be manipulated directly by changing various parameters in the options provided, hereby minimizing the need for any pre-requisite deep knowledge of design of the block. [4]

The formulation of the block diagram shown in Figure 1 is carried out by replacing the modules by various blocks, designed to carry out the work assigned. The mapping of the different blocks available in Lab View to the different units present in the block diagram is shown in Figure3.

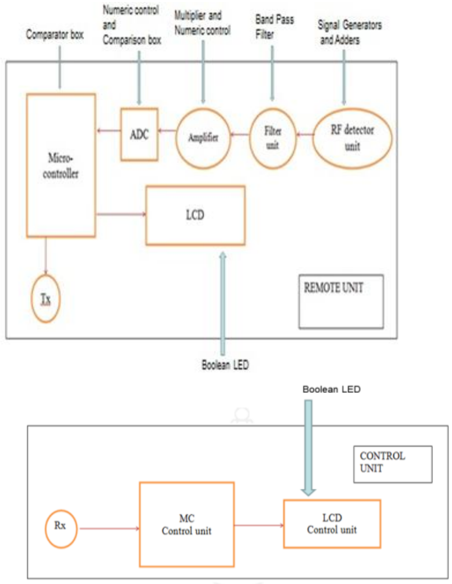

Fig3: Lab View Formulation For The Proposed System.

IV.SYSTEM IMPLEMENTATION

A. RF Detector

A simple discrete component RF detector circuit is used to detect mobile phone usage. The circuit uses an operational amplifier (Op-Amp) to sense the presence of an activated cell phone from a distance of around 1m. The simple circuit can detect any activity of a mobile phone such as incoming or outgoing voice, voicemail, texting, and data. The phone shouldn't be in air-plane mode. If a cell phone signal is detected the circuit will blink a LED or it could also be used to sound a buzzer. It is important that the phone must be transmitting and the only time a phone is transmitting is when it is receiving or sending voice, text, internet or data. Sensitivity can be adjusted on the circuit by adjusting the potentiometer. This circuit is made very simple using least amount of components.The circuit used for detection is shown in Figure4.

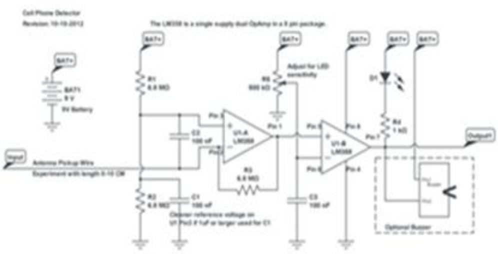

Fig 4: The RF Detector Circuit used to Detect Mobile Phone Usage.

The circuit is not a tuned circuit. The first Op Amp acts as a comparator. Any difference between + and - pins is reflected on the output. The circuit uses an inexpensive part, the LM358 which operates up to 1MHz. 1 Megahertz is fine as high frequency response is not required and also radiated energy is of importance than the frequency. The circuit worked well detecting the T-Mobile which operates at 800MHz - 1.7 GHz. [5].Than the discrete components a readily available IC like LT3358 could also be used for RF signals detection.

The circuit was initially simulated using PSpice before implementing it practically. The simulated circuit and output is discussed in results section. The antenna in the detector circuit was detecting only mobile frequency signal of 800MHz to 900MHz. It was also observed that the signal transmitted between the wireless transmitter and receiver was not getting detected. Hence a filter was not required. The signal strength was improved by a unity gain voltage follower and then given to the ADC for conversion.

B. Arduino

Arduino UNO board used in the system is shown in Figure Arduino Uno is a microcontroller board having the microcontroller ATmega328.

Fig 5: Ardino UNO Board

It contains the features required to support the microcontroller and it just needs to be connected to a computer using a USB cable. It can also be powered by an AC-to-DC adapter or battery to get started. The Arduino board has an inbuilt ADC. Hence use of an external ADC was not required. The amplified output of the detector is given to the ADC present in the Arduino board.

Arduino IDE 1.0.5-R2 is the firmware used for programming. The output at each stage can be checked through the serial window present in the IDE. Each time a new code is written it is automatically compiled and the controller in the board gets programmed. The program written in Arduino is similar to C. Arduino IDE 1.0.5-R2 does not support assembly language.

C. Wireless Transmitter and Receiver

The wireless transmitter STT-433 [6] used in the prototype design is shown in Figure 6. The STT-433 is ideal for remote control applications where low cost and longer range is required. The transmitter operates from a 1.5-12V supply, making it ideal for battery-powered applications. The transmitter employs a SAW-stabilized oscillator, ensuring accurate frequency control for best range performance.

Fig 6: STT-433 Wireless Transmitter

OOK (On Off Keying) modulation is a binary form of amplitude modulation. When a logical 0 (data line low) is being sent, the transmitter is off, fully suppressing the carrier. In this state, the transmitter current is very low, less than 1mA. When a logical 1 is being sent, the carrier is fully on. In this state, the module current consumption is at its highest, about 11mA with a 3V power supply. OOK is the modulation method of choice for remote control applications where power consumption and cost are the primary factors. Because OOK transmitters draw no power when they transmit a 0, they exhibit significantly better power consumption than FSK transmitters. OOK data rate is limited by the start-up time of the oscillator. The start-up time of the oscillator determines the maximum data rate that the transmitter can send. The oscillator start-up time is on the order of 40µs, which limits the maximum data rate to 4.8 Kbps. The transmitter is basically a negative resistance LC oscillator whose center frequency is tightly controlled by a SAW resonator. SAW (Surface Acoustic Wave) resonators are fundamental frequency devices that resonate at frequencies much higher than crystals.

The wireless receiver STR-433 [7] used in the prototype design is shown in Figure 7. The STR-433 is ideal for short-range remote control applications where cost is a primary concern. The receiver module requires no external RF components except for the antenna.

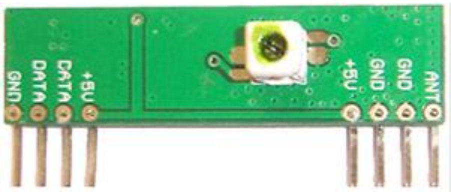

Fig 7: STR-433 Wireless Receiver [4]

The STR-433 uses a super-regenerative AM detector [8,9,10] to demodulate the incoming AM carrier. A super regenerative detector is a gain stage with positive feedback greater than unity so that it oscillates. An RC-time constant is included in the gain stage so that when the gain stage oscillates, the gain will be lowered over time proportional to the RC time constant until the oscillation eventually dies. When the oscillation dies, the current drawn from the gain stage decreases, charging the RC circuit, increasing the gain, and ultimately the oscillation starts again. In this way, the oscillation of the gain stage is turned on and off at a rate set by the RC time constant. This rate is chosen to be super-audible but much lower than the main oscillation rate.

Detection is accomplished by measuring the emitter current of the gain stage. Any RF input signal at the frequency of the main oscillation will aid the mainoscillation in restarting. If the amplitude of the RF input increases, the main oscillation will stay on for a longer period of time, and the emitter current will be higher. Therefore, the original base-band signal can be detected by simply low-pass filtering the emitter current.

The data slicer converts the base-band analog signal from the super-regenerative detector to a CMOS/TTL compatible output. Because the data slicer is AC coupled to the audio output, there is a minimum data rate. AC coupling also limits the minimum and maximum pulse width. Typically, data is encoded on the transmit side using pulse-width modulation (PWM) or non-return-to-zero (NRZ). Data is sent as a constant rate square-wave. The duty cycle of that square wave will generally be either 33% (a zero) or 66% (a one). The data slicer on the STR-433 is optimized for use with PWM encoded data, though it will work with NRZ data if certain encoding rules are followed.

V. RESULTS

The proposed system is formulated using LabView. The snapshots of the formulation is shown in Figure 8.

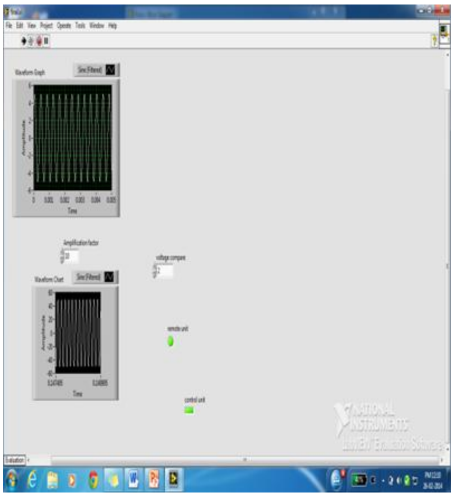

Figure 8(a) Block Diagram of the Proposed System in Lab View. Figure 8(b) Front Panel of the Proposed System in LabView.

The proposed system working is verified in LabView [11]. The Detector detects the RF signal and turns the LED in Remote unit ON for a specific time. If the RF signals continue to be present then the LED in control unit is turned ON.

The filter receives only the required frequency RF signal and the multiplier block amplifys the signal depending on the amplification factor mentioned as numeric control. The analog signal is then converted to digital using the comparison box and numeric control. A simple comparator behaves as a microcontroller which checks whether the received signal value is zero or a non- zero value. If it is a non-zero value then the LED in remote unit is turned ON and the checking process continues for 't' seconds. If the signal still persists then LED in control unit is turned ON.

The RF detector circuit simulated in PSpice is shown in Figure 9. The circuit simulation result is shown in Figure 10.

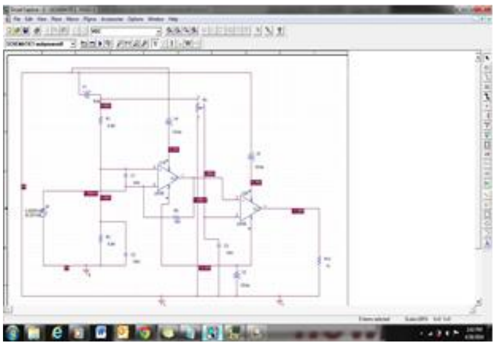

Fig 9: RF Detector Circuit Simulated In Pspice

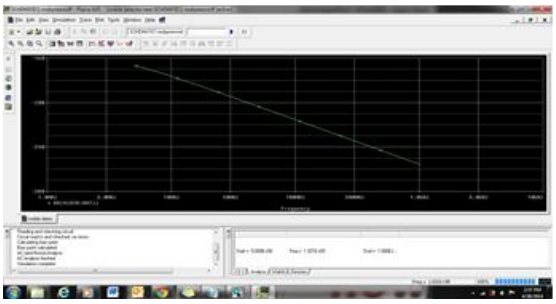

Fig 10: Frequency Response of RF Detector Circuit

The hardware implementation of RF Detector circuit is shown in Figure 11. The LED in the circuit glows when the circuit is powered up.

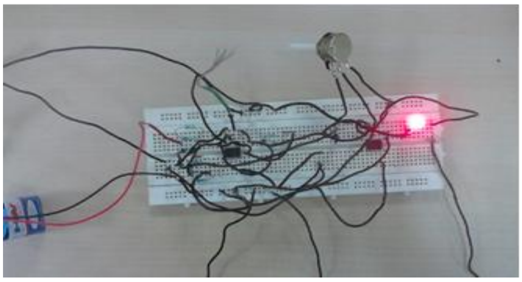

Fig 11: Hardware Implementation Of RF Detector Circuit

Figure 12 shows the signal in CRO when the mobile signal is detected by the circuit.

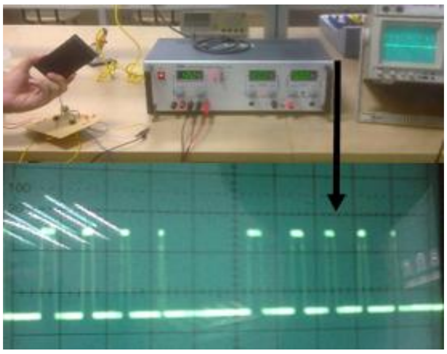

Fig 12: RF Detector Output When A Mobile Phone Is Operated.

Figure 13 shows the signal in CRO when the mobile signal is not detected by the circuit.

When mobile phone is not operated no display will be there in both control unit and remote unit as shown in Figure 14.

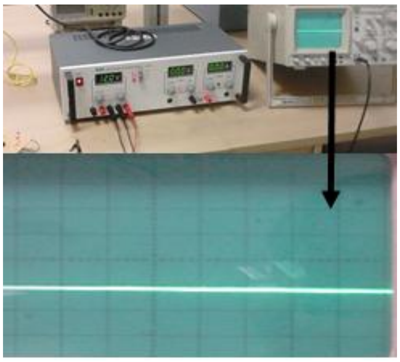

Fig 13: RF Detector Output when no Mobile Phones is Operated.

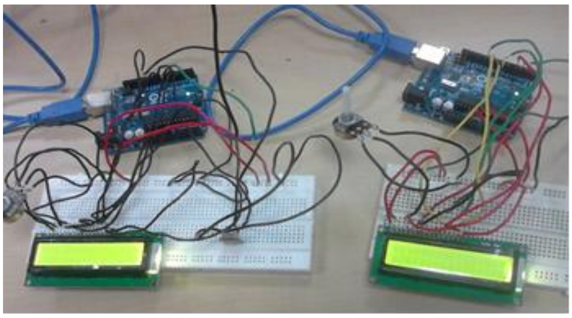

Fig 14: No Display when no Phone is Operated

When mobile phone is operated then "SWITCH OFF PHONE" is displayed in the remote unit as shown in Figure 15.

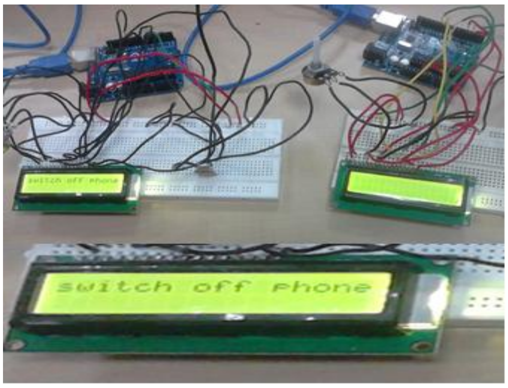

Fig 15: Message Displayed in Remote unit when Mobile Phone is Detected.

If the signal is detected continuously for a longer duration of time then the location where mobile phone signal is detected is sent to the control unit. The location is displayed in control unit as shown in Figure 16.

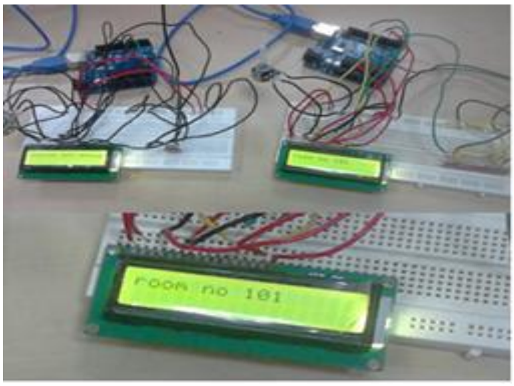

Fig 16: Room Number Displayed in Control Unit when Mobile Signal is Detected for Longer Duration.

The RF detector signal is given to analog pin of the Arduino which converts the analog signal to digital form. Analog voltage of 0 to 5 volt corresponds to 0 to 1023 steps. A threshold of 800 steps is selected. Any voltage which corresponds to a digital value below this reference is treated as a logic '0' and value greater than 800 is treated as logic '1'. 0 informs that no mobile signal is found whereas a 1 informs that mobile signal is detected. This 1 or a 0 is obtained from the digital pin of Arduino. Based on this result messages are displayed. Figure 17 shows the serial window displaying 0 and 1 depending on mobile phone activity.

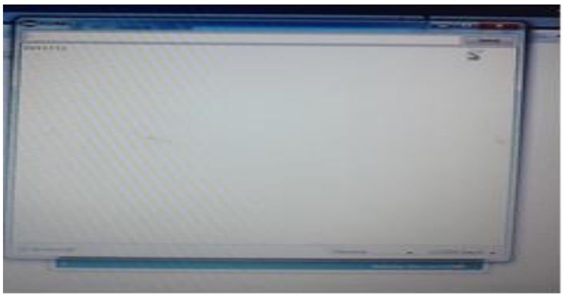

Fig 17: Serial Window Output of Arduino.

VI. CONCLUSIONS

The idea behind the proposed system was verified using LabView. The RF detection circuit was simulated in Pspice and verified. The prototype is designed and developed.

The remote unit detects the usage of mobile phones and displays a warning message. If the signal persists for a longer duration then the remote unit sends the location of mobile phone signal detected to the control unit. For transmitting the location information wireless transmitter-receiver is used. But the signal transmitted is not detected by the RF detector in the remote unit as the frequency and radiated energy are different.

The idea to implement better rules regarding mobile usage in non-mobile zones is expressed through this prototype. But there are few drawbacks. The range of mobile signal detection is just 1m and wireless transmitter-receiver range is 20m which is small. When implemented practically the range must be improved or else multiple remote units must be placed within a specified boundary which should be able to communicate with each other. Large display systems may be required to display suitable messages. Presently only one transmitter and receiver pair is used. When multiple transmitters are present the receiver must be able to identify the transmitter and the data sent by it.

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