Low Cost GSM Detector

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Abstract: *The aim of this paper is to present a low cost device that can detect GSM signals. The presented detector can be used generally for identifying the presence of a GSM emitter in certain proximity, more then to accurately localize the mobile device in some areas. In the first part of the paper, some aspects regarding the components of the device will be presented, along with general implementation issues. The second part is focused on measurement results and functional observations that sustain the utility of such a device.*

1. INTRODUCTION

Global System for Mobile Communications or GSM as it is well-known is a standard used in mobile communications worldwide. Even if the first applications were developed for mobile phones, many other devices can communicate using this method. For different reasons, the mobile devices are not allowed in some areas such as: airplanes (take-off or landing procedure), theaters, cinemas, churches, classrooms, etc. With or without intention, some people do not power off or get rid of the mobile devices when they are entering one of these disallowed locations.

The aim of this paper is to present a simple device that can detect the presence of a mobile phone that is still in use in some restricted areas.

In the first part of the paper, some aspects regarding the components of the device will be presented. The last part is focused on measurement results and functional observations.

2. THE EXPERIMENTAL DEVICE

The experimental device has five main components, at it is shown in figure 1:

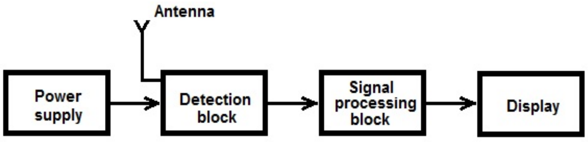

Figure 1 *The block diagram of the GSM detector*

The power supply used is a differential one and generates a voltage of ±9 V. In order to avoid external noise, a group of two 9 V battery cells can be used.

The detection block receives the signal from the antenna. The signal processing block amplifies and filters the signal in order to be visualized on a 10 LED-bar display in respect with the GSM signal intensity.

The detector's antenna must have an appropriate geometry in order to receive the signal with a specific frequency or a frequency range that we are interested in.

The antenna that we use was chosen from many versions found in the literature. This is a compact multiband (GSM/DCS/PCS/UMTS/Bluetooth/WLANs/Wi-MAX) planar monopole antenna, which contains multiple branches.

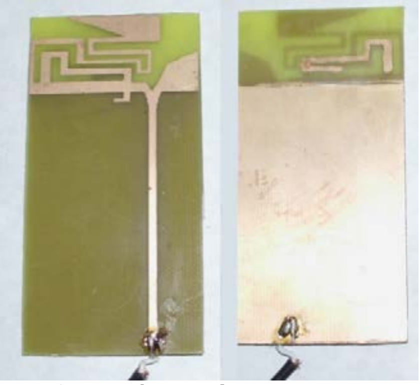

Figure 2 *The GSM detector's antenna*

The frequency range that can be received with this type of antenna is between 900 MHz and 5.5 GHz. [4]

The detection block is built from a single layer circuit board that contains an integrated circuit (LTC5505) and connection terminals. It also contains a small round antenna that can be observed in the right part of figure 3.

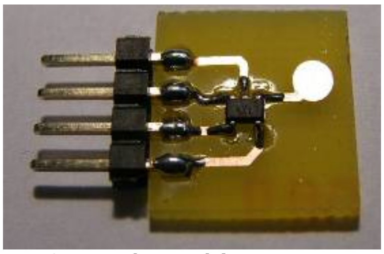

Figure 3 *The signal detector circuit*

LTC 5505 is an integrated radiofrequency detector dedicated to GSM networks applications. The main component of the detector is a Schottky diode used to convert the high frequency signal into a low frequency one. After this conversion, the signal is amplified, filtered and converted into an output voltage with the aid of a peak detector circuit.

The detection frequencies range is between 300 MHz and 3.5 GHz. The mentioned circuit converts the received frequency in voltage ranging from 0.25 to 1.7 V.[13]

The signal processing block contains two operational amplifiers: one used to increase the output signal of the converter and the other one to reverse the resulted voltage in order to be sent to the display block.

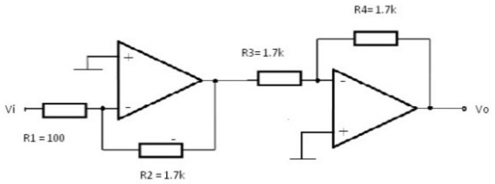

Figure 4 *The main part of the signal processing block*

As it is shown in figure 4, the input signal is reversed and amplified by 17 with the first operational amplifier (-R2/R1=-17), then the resulted signal is repeated and reversed again with the second amplifier (-R4/R3=-1).

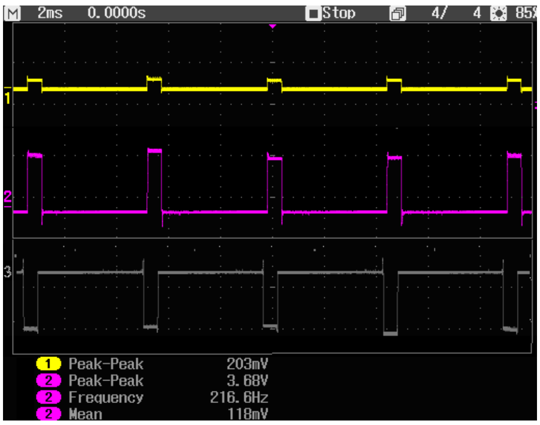

Figure 5 *The signal processing operating mode*

Figure 5 shows the operating mode of the signal processing block. The voltage from the detector, with a peak to peak value of 203 mV, is measured on the first channel. On the second channel the signal was amplified 17 times, then, on the third one the resulted voltage was reversed.

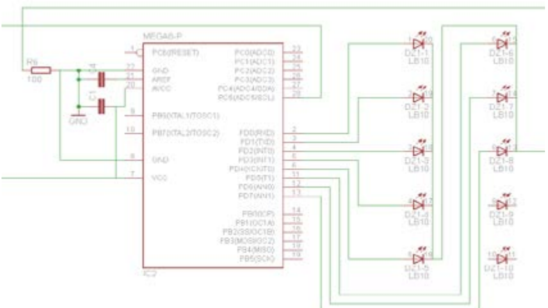

Figure 6 *The electric diagram of the display circuit*

In order to visualize the intensity of the detected GSM signal, a 10 LED-bar display is used. The graphic indicator is driven by an ATMEGA8 microcontroller, as figure 6 shows.

a) b) c) d)

Figure 7 *The illustration of four measuring tests*

Figure 7 presents four different indication of the display for the case when a mobile phone is at a different distance from the antenna: a) 60 cm, b) 40 cm, c) 20 and d) 5 cm.

3. THE EXPERIMENTAL RESULTS

After the device was built, some measurements were made in order to analyze the behavior of the GSM detector in various situations. The tests were focused on distance and angle between antenna and a mobile device, the presence of multiple emitters, the situations when the phone is ringing or is in conversation mode.

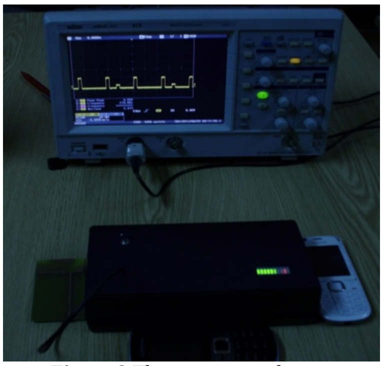

Figure 8 The experimental setup

In figure 9 three different situations are presented: on the first channel is the case when the mobile device is on conversation; on the second channel the device rings and on the third channel two devices, from different networks are present near the detector.

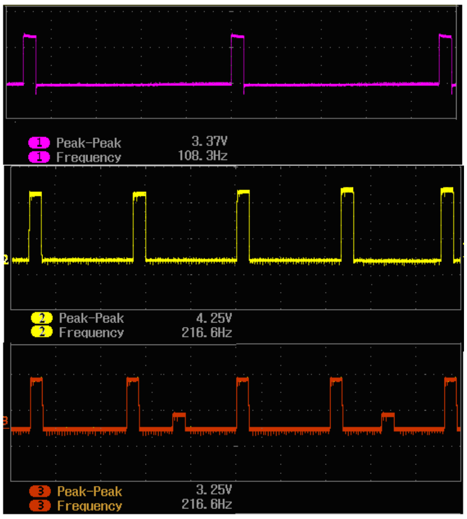

Figure 9 *The processed signal in various situations*

The measurements in this case were made keeping the mobile phones and antenna in same plane at 10cm distance between them.

As it is shown in the previous figure, the frequency when the phone is ringing is double in relation with the conversation situation. Also the amplitude of the signal is different between those two cases.

When a second phone is present near the antenna, it also can be detected because of the difference in frequency and amplitude of the two detected signals.

Considering the previous observation, a more specific identification of the mobile devices can be done if the distance or the angle between emitter and receiver is known.

3.1. Linear displacement of the detector

In order to analyze the behavior of the detector when a source is present in its vicinity, some tests were performed.

In figure 10, the detector's response to a linear displacement of the mobile phone is shown. In this case, the measurements were performed without an external antenna.

The results show that voltage peaks appear with a frequency around 108 Hz. The amplitude decreases when the source is at a bigger distance from the detector: 3.12 V at 10 cm, 2.5 V at 30 cm and 109 mV at 100 cm.

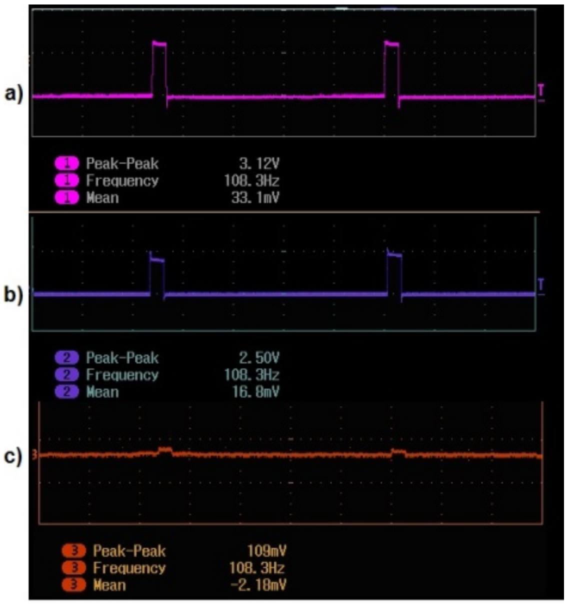

Figure 10 *The detector's response to a linear displacement without antenna: a) 10 cm; b)30 cm, c) 100 cm.*

As it is expected, when an antenna is present, the amplitude increases. Furthermore, the signals emitted from longer distances can now be detectable. The frequency remains the same, just the amplitude of the signal is modified: 3.37 V at 10 cm, 2.75 V at 30 cm and 593 mV at 100 cm.

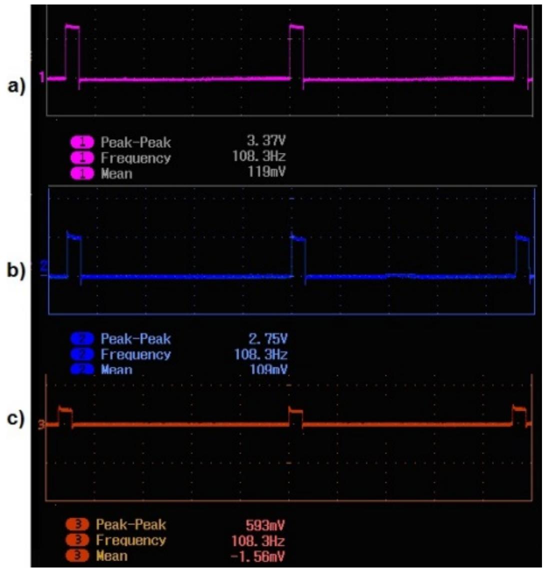

Figure 11 *The detector's response to a linear displacement with an antenna: a) 10 cm; b)30 cm, c) 100 cm.*

To emphasize the importance of the external antenna, a graphical representation of the two situations is presented in figure 12.

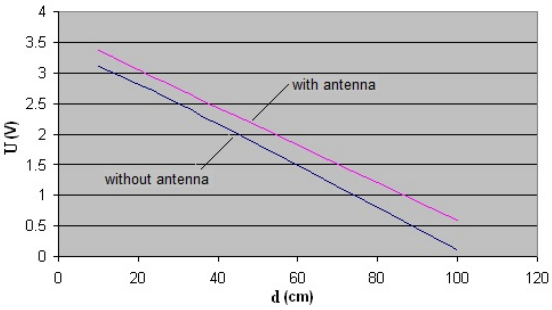

Figure 12 *The voltage variation in respect with the linear displacement of the source*

3.2. Angular displacement of the detector

The angular displacement can influence the amplitude of the measured voltage. Three sets of measurements were performed by displacing the emitter in a circle with a radius of 1 m, in three planes: XY, XZ and YZ.

Table 1 *Angular displacement test results*

The angle between the antenna and emitter (°)	Voltage amplitude (mV)		
	XY plane	XZ plane	YZ plane
0	393	380	380
30	225	340	340
60	200	280	280
90	359	393	359
120	198	322	322
150	207	229	234
180	312	300	300
210	203	203	220
240	137	176	187
270	327	312	327
300	260	308	320
330	210	280	324

In figures 13, 14 and 15 the characteristics of the measured voltage in respect with the angle between antenna and the cell phone are presented.

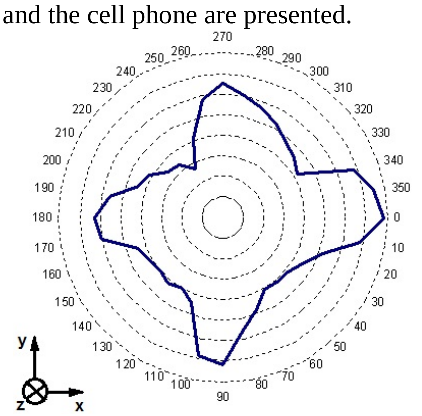

Figure 13 *The response to an angular displacement in XY plane*

The irregularities that appear in these graphs are the result of the procedure that we had applied. The antenna plane was kept at all times parallel to the plane of the mobile device.

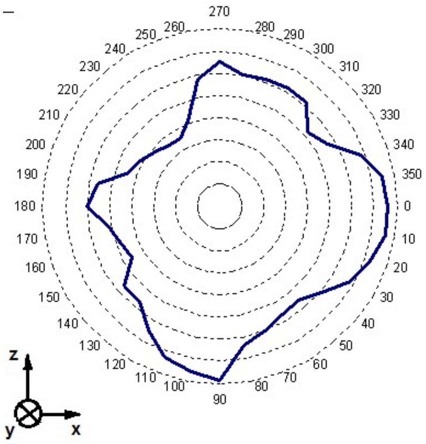

Figure 14 *The response to an angular displacement in XZ plane*

From each of those three cases we can conclude that the output signal of the GSM detector is different at any given angle. The manner in which those values are changing may be a problem in an accurate localization of the mobile device in some area. For this reason, the detector that was presented can more likely be used for identifying the presence of a GSM emitter in certain proximity.

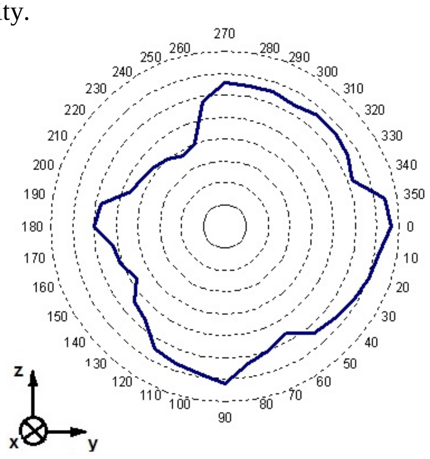

Figure 15 *The response to an angular displacement in YZ plane*

4. CONCLUSIONS

Considering the simplicity of the presented device, we can conclude that this GSM detector can be a viable solution for civil applications to identify the presence of a GSM emitter in certain proximity.

In order to analyze the behavior of the detector, when a source is present in its vicinity, some tests were performed. There were focused on distance and angle between antenna and a mobile device, the presence of multiple emitters, the situations when the phone is ringing or it is in conversation mode.

For a better detection and an accurate localization of the mobile device in some area certain improvements are necessary.

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