CARITAS UNIVERSITY AMORJI-NIKE, EMENE, ENUGU STATE

Caritas Journal of Engineering Technology

CJET, Volume 4, Issue 2 (2025)

Article History: **Received** *10th April 2025; Revised: 20th May, 2025; Accepted: 10th June, 2025*

DESIGN AND IMPLEMENTATION OF 900MHz MOBILE ELECTROMAGNETIC WAVE INTERFERENCE SYSTEM FOR EXAMINATION HALL PROTECTION

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Abstract

This work aimed at design and implementation of 900MHz mobile electromagnetic wave interference system for examination hall protection. The work focused on design and building of a system that can block the use of mobile phone by transmitting radio waves of the same frequencies as that of the mobile phone causing interference between mobile phone and the Base Transceiver Station. The objectives of the work include the design and building of a power supply that would distribute power to other parts of the system for operation; designing and constructing the intermediate frequency section which helps to generate the tuning frequency (noise) signal; designing and constructing the radio frequency section which helps to generate radio frequency signal that would create interference with signal from base transceiver station so as to block transmission between mobile phone and base transceiver station and integrating different sub-systems to form one single system. The system was tested for functionality and the test results showed that a stable noise signal of 7.09MHz from the intermediate frequency-section was generated. Result showed that a final output frequency of 900MHz from the antenna was obtained.

Keywords: Mobile jammer, Signal, electromagnetic wave, GSM, Signal-to Noise Ratio, Spoofing

1.0 INTRODUCTION

With the rapid advancement of wireless communication technologies, mobile devices have become ubiquitous in everyday life, including academic settings. However, during examination periods, these devices pose a significant threat to academic integrity due to the potential for cheating via calls, messaging apps, or internet access. The 900 MHz frequency band commonly used by Global System for Mobile Communication (GSM) is particularly exploited for this purpose (Zorn et al, 2011). Global System for Mobile Communication (GSM) is an acronym defined by International Telecommunication Union (ITU) as Global System for Mobile communications (Gunnar 2013). It is a digital technology that mobile telecommunications industry uses to provide mobile communication networks. These create the wide use of mobile phones and these could create some problems as the sound of ringing becomes annoying or disrupting (Ali et al., 2011). This can happen in some places like conference rooms, court room, libraries, lecture rooms and mosques .Therefore, an effective and localized method to disable communication within this band is essential.

The proposed system presents a mobile electromagnetic wave interference jamming system designed to block 900MHz signals within examination halls. The system is compact, portable, and efficient in disrupting unauthorized wireless communications, thereby promoting fair examination practices. Unlike traditional large-scale jammers, this mobile system can be easily moved and deployed as needed, offering flexibility and targeted protection without interfering with nearby areas or critical communication infrastructure. The proposed system operates by emitting high-powered electromagnetic noise within the 900MHz frequency range. This artificial noise interferes with the communication between devices, rendering them unable to send or receive data effectively (Shah el al., 2008). The key components of the system include signal or frequency generator (such as a VCO or RF oscillator) used to produce a sweeping or fixed-frequency signal within the 900MHz band. This signal is designed to overlap with the operating frequencies of GSM devices. The RF power amplifier increase the strength of the jamming signal, a power amplifier boosts the output from the signal generator, ensuring effective coverage across a standard-sized examination hall. Antenna System: A high-gain omni directional antenna is connected to the amplifier to radiate the jamming signal uniformly. In some cases, directional antennas may be used for focused jamming (Campell and Park 2008). The Control Unit consists of a microcontroller (e.g., Arduino or Raspberry Pi) which provides user control, enabling ON/OFF switching, frequency tuning, and system monitoring (e.g., temperature or battery status) (Mahato and Vimala 2015). The Power Supply unit consist of a rechargeable battery or portable power bank supplies energy, making the unit mobile and independent of external power sources. All components are housed in a compact, heat-resistant casing with ventilation to ensure portability and durability.

Therefore, the main aim of this work was design and build a system that can block the use of mobile phone in such places where their use are not required by transmitting radio waves of the same frequencies as that of the mobile phone causing interference between mobile phone and the Base Transceiver Station, hence the mobile phone displays "no network" on the screen.

Specifically, the objectives of the work are;

- Designing and building a power supply that would distribute power to other parts of the system for operation.
- Designing and constructing the Intermediate Frequency section which helps to generate the tuning frequency (noise) signal.
- Designing and constructing the Radio Frequency section which helps to generate RF signal that would create interference with signal from BTS so as to block transmission between mobile phone and BTS.
- Integrating different sub-systems to form one single system, that is the GSM mobile phone jammer device.

2.0 JAMMING TECHNIQUES

There are different ways to jam an RF device. The three fundamental types are (Olayiwola and Aliu (2022):

2.1 Spoofing

Here, the device forces the mobile to turn off itself. This type is very difficult to be implemented since the jamming device first detects any mobile phone in a specific area, then the device sends the signal to disable the mobile phone. Some types of this technique can detect if a nearby mobile phone is there and sends a message to tell the user to switch the phone to the silent mode (Intelligent Beacon Disablers).

2.2 Shielding Attacks

This is known as TEMPEST or EMF shielding. This kind requires closing an area in a faraday cage so that any device inside this cage cannot transmit or receive RF signal from outside of the cage. This area can be as large as buildings, for example.

2.3 Denial of Service

This technique is referred to DOS. Thus, the device transmits a noise signal at the same operating frequency of the mobile phone in order to decrease the signal-to noise ratio (SNR) of the mobile under its minimum value. This kind of jamming technique is the simplest one since the device is always on.

3.0 MATERIALS AND METHOD

3.1 Materials

The materials used include: capacitors, integrated circuit, inductors resistors, battery, transistors Jumper wires, circuit boards, solder wire, Multisim software for circuit design, soldering gun, solderless breadboard Digital multimeter. The jamming system device consists of three main sections namely; the power supply unit, IF unit and radio frequency unit.

3.1.1 The power supply

The power supply section comprises of a DC voltage source of 9V. This is because the 555 timer IC uses a voltage source with the range of 4.5V to 16V and is able to produce a reasonable output and generate a frequency of 7.09MHz from 9V.

3.1.2 The IF section

It consists of the 555 timer IC, two resistors, three capacitors .The IC 555 timer was used because of its voltage range (4.5V to 16V) which is capable of producing the noise signal that is good enough to be amplified and also because of its low cost and availability in the market.

3.1.3 IC 555 timer

IC 555 timer is a one of the most widely used IC in electronics and is used in various electronic circuits for its robust and stable properties. It works as square-wave-form generator with duty cycle varying from 50% to 100%. Duty cycle is a proportion of time during which a component, device, or a system is operated. It can be expressed as a ratio or percentage.

Oscillator and can also provide time delay in circuits. The 555 timer got its name from the three 5k ohm resistor connected in a voltage-divider pattern which is shown in the Figure I. A simplified diagram of the internal circuit is given in Figure 2 for better understanding the full internal circuit consists of over more than 16 resistors, 20 transistors, 2 diodes, a flip-flop and many other circuit components. IC 555 timer is a well-known component in the electronic circles but what is not known to most of the people is the internal circuitry of the IC and the function of various pins present there in the IC. Table 1 shows the Internal structure of the IC 555 timer.

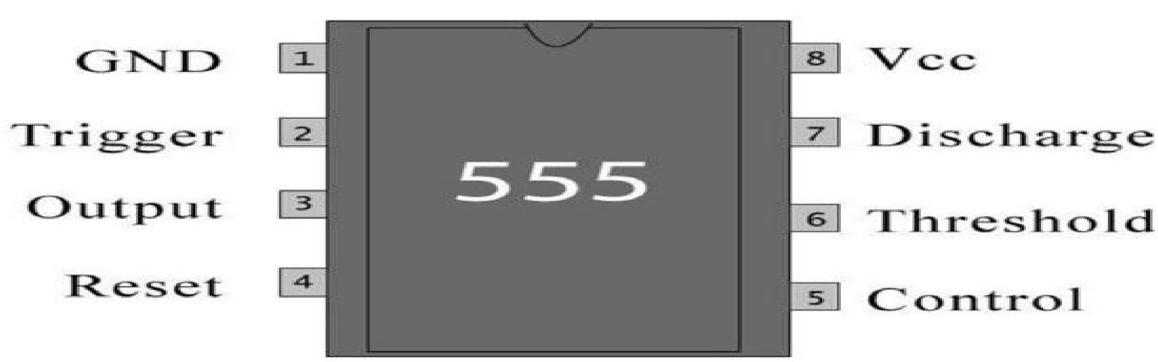

Figure 1: IC 555 timer

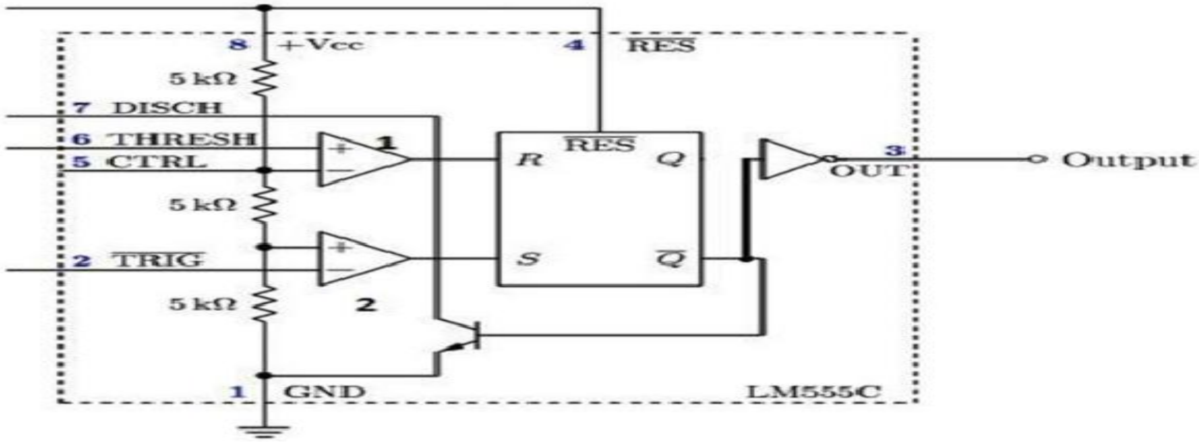

Figure 2: Internal structure of the IC 555 timer

Table 1: Function of different pins of IC 555 timer

Pin	**Pin Name**	**Input/Output**	**Function**
1	GND	INPUT	Provides zero voltage rails to the integrated circuit to divide the supply potential between the 6.8kΩ and 82kΩ resistors.
2	TRIGGER	INPUT	The trigger input is used to set the output of the Flip-Flop to HIGH state by applying a voltage equal to or less than Vin/2.
3	OUTPUT	OUTPUT	It is the output PIN of the IC connected to the Q-bar of the Flip-Flop.
4	RESET	INPUT	This PIN is used to reset the output of the Flip-Flop regardless of the initial condition of the Flip-Flop. It is an active LOW PIN so it is connected to HIGH state to avoid noise interference. Most of the time is connected to supply voltage unless reset operation is required
5	CONTROL VOLTAGE	INPUT	It's connected to the inverting input. It's used to override the inverting voltage to change the width of the output signal irrespective of the RC timing network. Control voltage input to control charging and discharging of external capacitor
6	THRESHOLD	INPUT	This PIN is connected to the non-inverting input of the first comparator. The output of the comparator is high when the threshold voltage is more than (2/3)Vin thus resetting the output "Q" of the FlipFlop from high to Low.
7	DISCHARGE	INPUT	This PIN is used to discharge the timing capacitors (capacitor involved in the external circuit to make the IC behave as a square wave generator) to ground when the output of PIN 3 is switched to low.
8	VCC	INPUT	This PIN is used to provide IC with the supply voltage for the functioning and carrying of the different operations to be fulfilled by the 555 timer.

3.1.3.1: Determination of R4, R5 and the output of the 555 timer

Method 1

By using astable oscillator calculator

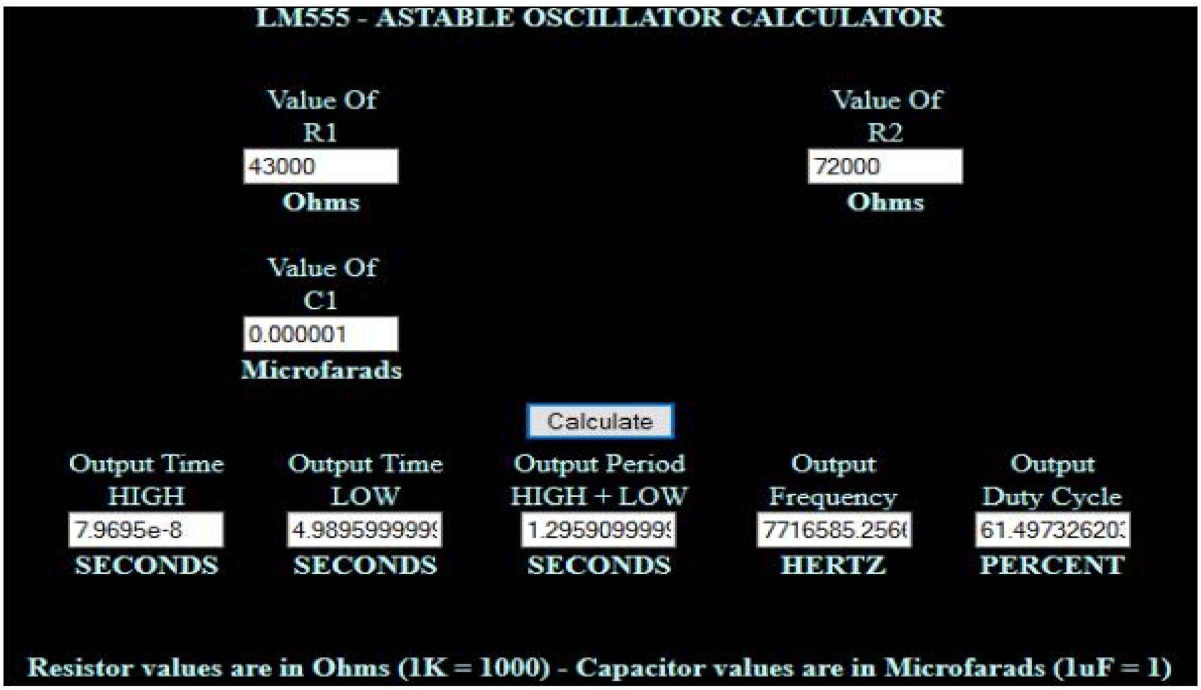

Figure 3: Astable oscillator calculator

Method 2
By using the formula of 555 Oscillator Frequency Equation
t1 – capacitor charge "ON" time is calculated as:

t1 = 0.693(R4+R5) C7 (2)

t1 = 0.693(43000+72000)*($1x10^6$) = 0.079695 = **80ms**
t2 – capacitor discharge "OFF" time is calculated as:
t2 = 0.693 x R5 x C7 (3)

t2 = 0.693 x 72000 x ($1x10^{-6}$) = 0.049896 = **50ms**
Total periodic time (T) is therefore calculated as:
t1 + t2 = 80ms + 50ms = **130ms** (4)

The output frequency, f is therefore given as:

$$F = \frac{1}{T}$$

$$F = \frac{1}{130ms} = 0.0076923 = \mathbf{7.72MHz}$$

$$\text{Duty cycle} = \frac{R4+R5}{(R4+2R5)} = \frac{43000+72000}{(43000+2x72000)} = \frac{115000}{187000} = \mathbf{0.61 = 61\%}$$

Changing the values of R4 and R5

(**a**) Increasing the values of R4, R5 it gives us a longer period of time and higher percentage of duty cycle and lower frequency than the expected output values.

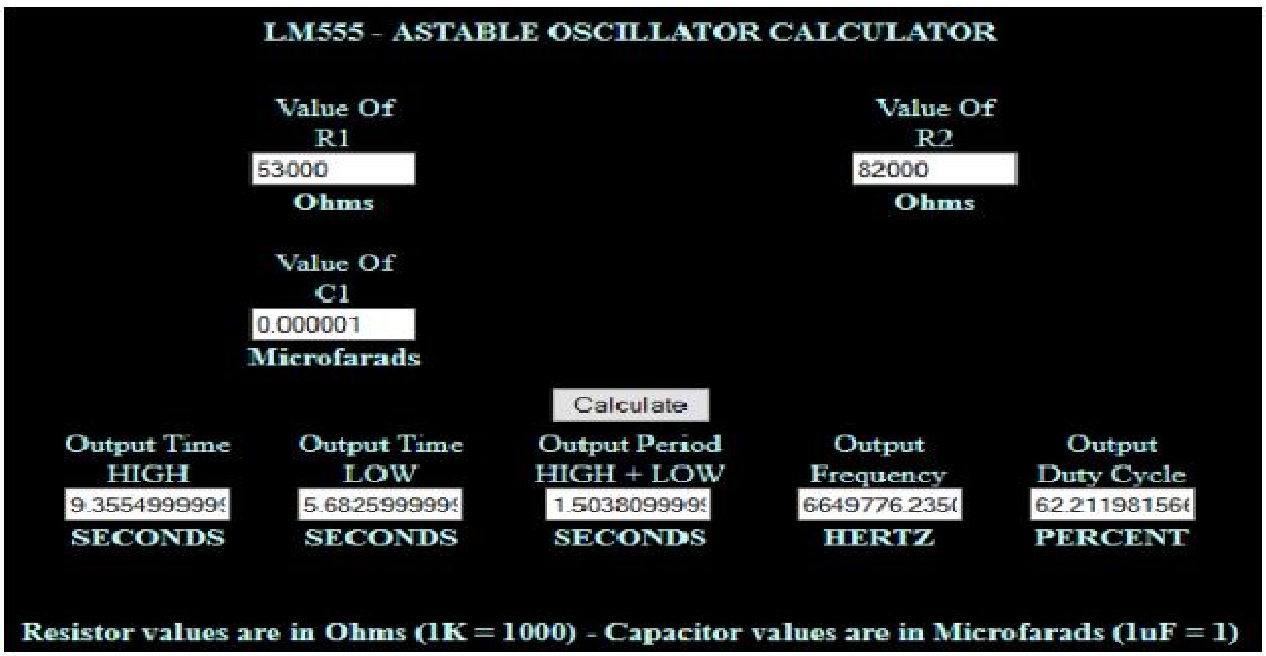

Figure 4: Increasing the values of R4 and R5

b) Decreasing both the values of R4 and R5 it gives us a short period of time and small percentage of duty cycle and higher frequency than the output values we were expecting.

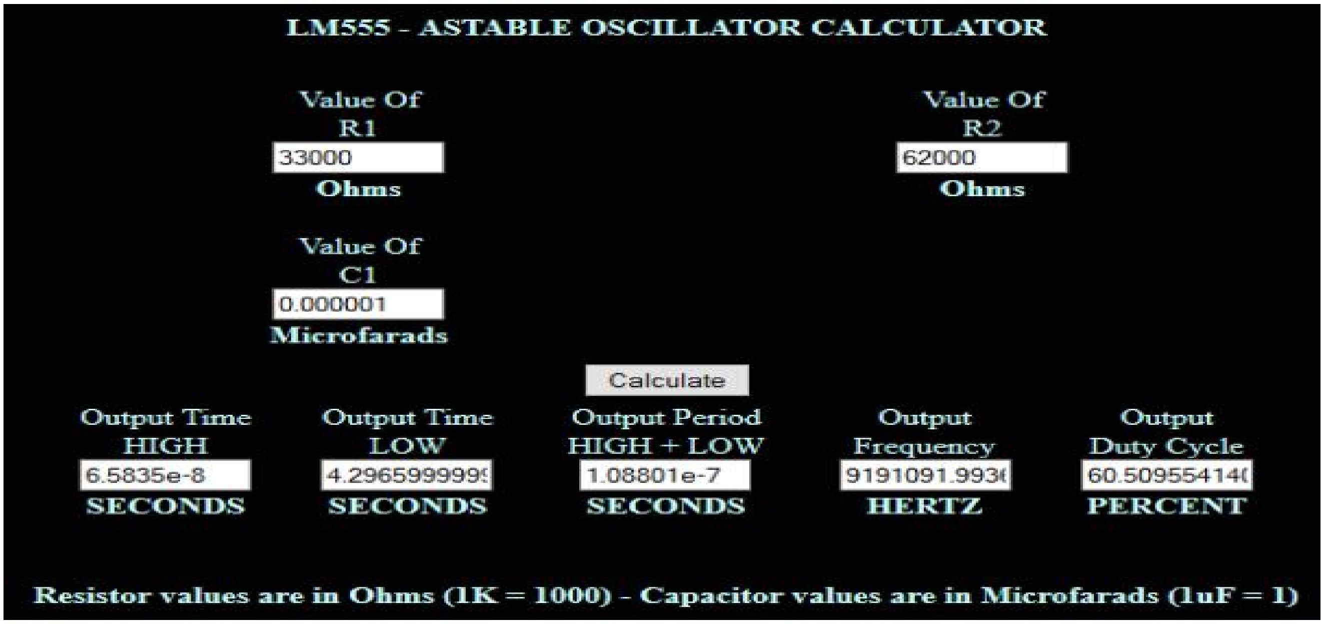

Figure 5: Decreasing the values of R4 and R5

3.1.3.2 The IC 555 time operating modes

Astable mode

It is also known as self-triggering or free running mode. It has no stable state. It has two quasi stable states that automatically changes from one to another. It changes from high to low state and low to high state without any trigger input after pre determine time. This mode is used to generate square wave oscillations, clock pulse, PWM wave (Muhammed et al., 2017).

Monostable mode

This is single shot mode. It has one stable state and one quasi stable state. It jumps into quasi stable state from stable state when trigger input is applied and comes back to stable state after pre determine time automatically. It is used in generating pulses, time delay (Sitati el al., 2016).

Bistable mode

This is flip-flop mode. It has both stable states. Two different trigger inputs are applied to change the state from high to low and low to high. It is used in automatic switching applications, to generate pulse of variable time (Umratkar et al., 2019).

The change of state from high to low and low to high results into generation of squire wave (noise signal). This noise signal is of value 7.09MHz.The noise signal is linked to the next section by C4 capacitor. Capacitor C3 is used to store excess charge and releases it when necessary.

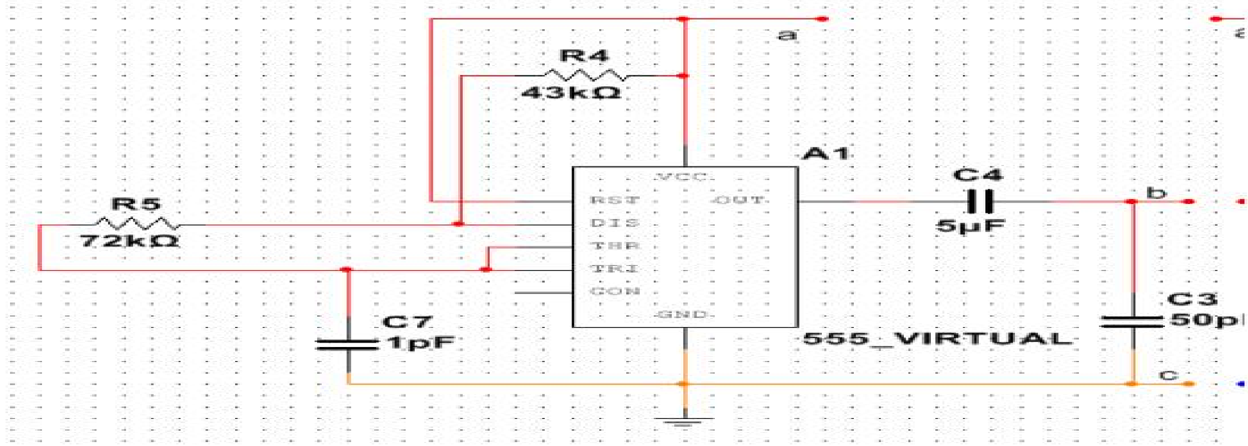

Figure 6: IF-section

3.1.3.3 The RF section

It produces the jamming signal. instead of using the Voltage controlled oscillator to generate the RF signal; The high frequency transistor generates the RF signal since they are cheaper than the VCO integrated circuit. Figure 2 is the design of the RF-section and the power supply inclusive.

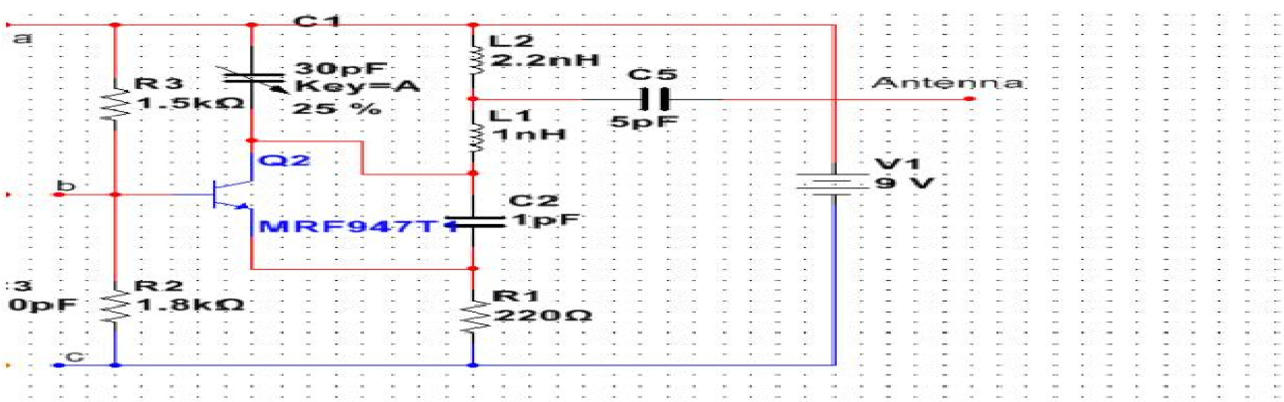

Figure 7: RF section

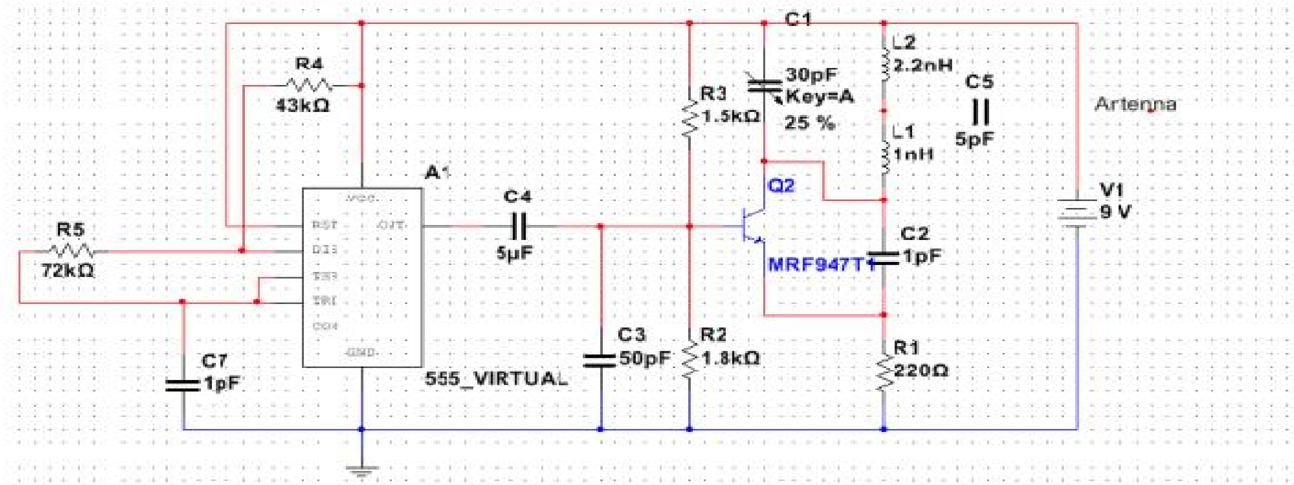

Figure 8: A complete schematic diagram of a mobile phone jammer system

3.1.4 The RF- Section

This has the transistor, variable capacitor, antenna, inductors, biasing resistors and capacitors. The RF-unit generates the output.

3.1.4.1 Transistor MRF947T1

This transistor uses a potential divider network to bias the transistor base. The power supply Vcc and the biasing resistors R2 and R3 set the transistor operating point to conduct in forward active mode. With no signal current flow into the base, no collector current flows (transistor is in cut-off) and the voltage on the collector is the same as the supply voltage Vcc. A signal current into the base causes a current to flow in the collector which causes voltage drop across it hence collector voltage drops.

The direction of change of collector voltage is opposite to the direction of change on the base, the polarity is reversed thus the common emitter configuration produces a large frequency amplification (frequency swings around 900MHz).

3.1.4.2 R2 and R3 values

The values of R2 and R3 were obtained from the MRF947T1 transistor Datasheet which gave us the maximum range of the collector-emitter voltage (max = 10V)

Table 2: MRF947T1 Transistor Datasheet

Parameter	Maximum Value
Collector- Base Voltage	20v
Collector Emitter voltage	10v
Emitter-Base voltage	1.5v
Transition frequency	900MHz

The 5.86V resulted to the preferred output frequency.

Give, emitter voltage = V_E = 5.86V;

V_E =5.86v

$V_{R2} = V_{RE} + V_{BE}$ (6)

= 5.86 + 0.7=6.56V

$I_B = I_c/\beta$ (7)

For NPN transistor, the amplifier gain is given by β = 100.

Implying;

I_b= 35mA / 100

But current through $I_{R2\ is}$ 10 times the current through I_b, hence;

$I_{R2} = 10 * I_b$ (8)

= 10 * 0.35

= 3.5mA

I_{R2} = 0.35mA

$R_2 = V_{R2}/I_{R2}$ (9)

= 6.56V / 3.5mA = **1.8KΩ**

$V_{R3} = V_{CC} - V_B$ (10)

$I_{R3} = I_{R2} + I_b$

= 3.5*10-3 + 0.35*10-3 = **3.85mA**

$R_3 = V_{R3} / I_{R3}$ (11)

= 5.86 / 3.85*10^{-3} = **1.5kΩ**

3.1.4.3 Determination of the efficiency and class of operation of MRF947T1 transistors

Using voltage division

Voltage through R2 is given by

$$VR2 = \left(\frac{R2}{R2+R3}\right) \times Vcc \quad (12)$$

where;

VCC = 9V power supply

VR2 = Voltage through resistor R2

$$VR2 = \left(\frac{1.8}{1.8 + 1.5}\right) \times 9$$

VR2 = (1.8 ÷ 3.3) × 9 = 4.9

The simulated output current I_{dc} through the transistor =25.1mA

Efficiency = (25.9 ÷ 225.9) × 100% = **11.5%**

The maximum theoretical efficiency of class-A amplifier is 50%. This amplifier having efficiency of 11.5% implies that it is a class-A amplifier. It conducts current throughout the entire cycle (3600) of input signal. Resistor R3 is connected to the Vcc and the positive terminal (base) of the transistor hence forward biasing the transistor.R3 also regulate the amount of current entering the base of the transistor. R1 made to be small so as to allow large voltage gain at the output of the transistor hence high frequency. C2 is a DC blocking capacitor (it blocks the dc components and allows AC signal to pass through).

3.1.4.4 Variable capacitor

A variable capacitor is a capacitor whose capacitance may be intentionally and repeatedly changed mechanically or electronically. Variable capacitors are often used in L/C circuits to set the resonance frequency, e.g. to tune a radio (therefore it is sometimes called a tuning capacitor or tuning condenser), or as a variable reactance, e.g. for impedance matching in antenna tuners. A variable capacitor is a special type of capacitor, most commonly used for tuning radios, which allows the amount of electrical charge it can hold to be altered over a certain range, measured in a unit known as farads. The capacitance of 30pf was used which was able to tune our frequency to a desirable range that is around 900MHz.

3.1.4.5 The inductors L1 and L2

An inductor connected to a capacitor forms a tuned circuit, which acts as a resonator for oscillating current. Tuned circuits are widely used in radio frequency equipment such as radio transmitters and receivers, as narrow band pass filters which help to select a single frequency from a composite signal, and in electronic oscillators to generate sinusoidal signals.

These inductors connected in series with a capacitor to provide discrimination against unwanted signals and also to maintain a constant current. Another reason for connecting these two inductors is to remove Low-frequency signals when they are passed through these inductors. And therefore, High-frequency signals that pass through the capacitor (high pass) and are sent to the output.

Calculation of inductance value

Method 1: using formula

$$L = \frac{d^2 + n^2}{18d + 40l} \tag{13}$$

Where L = inductance in micro henrys, D = coil diameter in inches , l = coil length in inches
N = number of turns

Method 2: using inductor calculator

This is a calculator that allowed us to enter the different values of the inductor parameter and automatically calculates the inductance value.

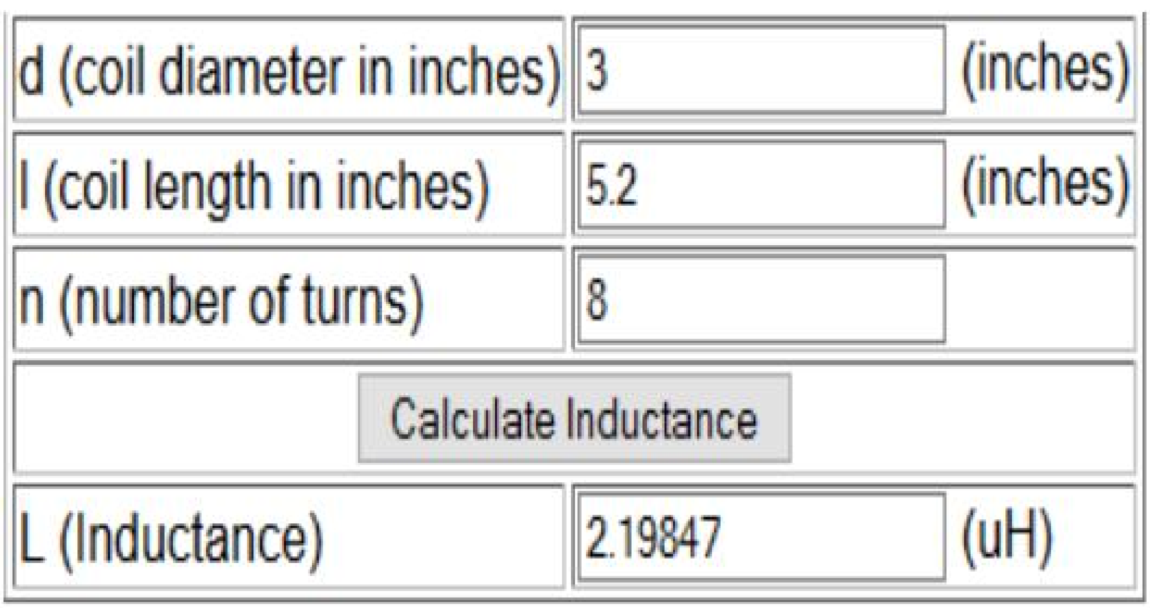

Figure 9: Calculation of inductance L1 using inductance calculator

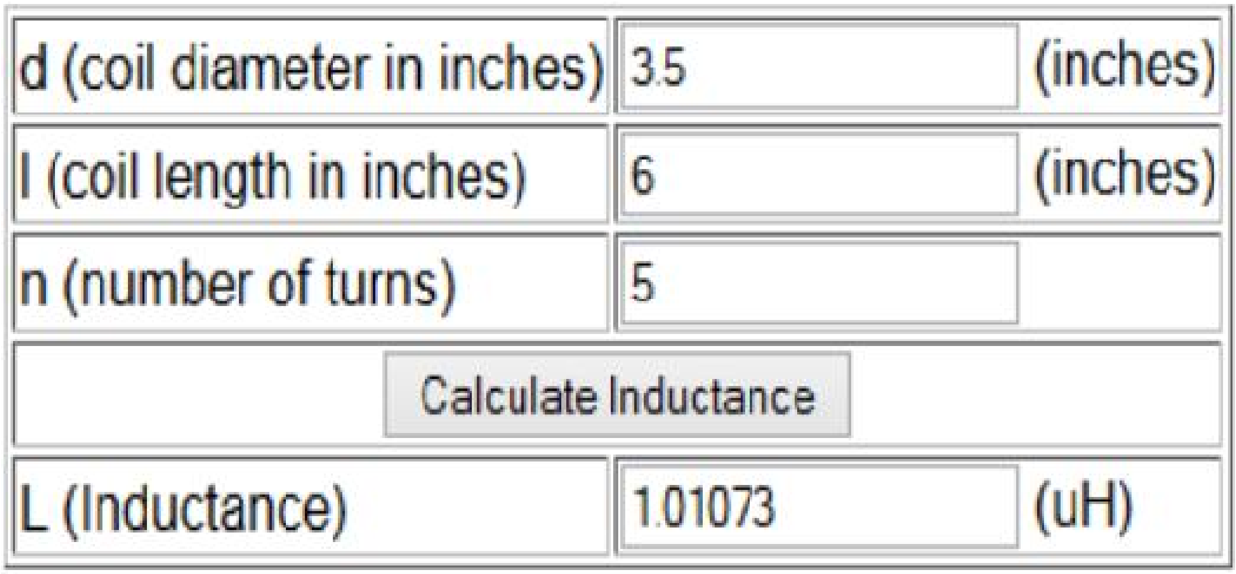

Figure 10: Calculation of inductance L2 using inductance calculator

From the calculator we were able to obtain the approximate value of L1 and L2. Note that in a practical environment, it is very difficult to obtain the exact value of an inductor and this why we are talking of the approximate values.

3.1.5 The Antenna

The monopole antenna was used since the radiation pattern is Omni-directional.

Omni directional antenna radiates /transmitting signal in all direction that is 360 degree. This antenna jam any mobile phone close at any angle. The impedance matching ability with the impedance of other transmission system gave optimal power transfer.

Table 3: Summary of Components and their functionality

Power Supply		
1	9volts	Maintains power to the entire circuit
IF SECTION		
1	IC 555 Timer	Produces the noise signal that will be amplified and interfere with the signal from the BTS to mobile unit.
2	R4 and R5 Resistors	Charge the capacitor C7 which discharges through R5
3	C7 Capacitor	Stores charges for the IC 555timer
4	C4 Capacitor	Couple the produced signal of 7.MHz to a point that it can be amplified and transferred to another stage
5	C3 Capacitor	Stores charges and discharges when necessary
Radio Frequency Section		
1.	MRF947TI Transistor	Amplifies high frequency upto 800MHz

2	Inductors	Consists the tuned circuit which acts as a resonator for oscillating current
3	Variable Capacitor	For tuning /varying frequency so as to get the appropriate range
4	R2 and R3	For biasing the transistor and regulates the current that enters the base of the trasistor
5	Capacitor C2	Blocks DC components and other AC signal to pass through
6	Resistor R1	Load resistor, which gives the output of the transistor
7	Capacitor C5	Cuts off the ripple from output signal before sending to antenna
8	Antenna	Radiates radio wave having the same frequency as that of mobile phone so as to interfere with the BTS signal
9		

4.0 RESULTS AND DISCUSSION

4.1 Testing

The examination of the output of a system was done so as to determine how well or faulty it works. After the completion of the circuit construction the schematic circuit was subjected into test. The test was done by simulation at two main distinct stages;

4.1.1 Stage one

This stage is known to be the IF-section of the system and therefore, the main intension is to obtain its output. At this stage we wanted to find out if noise signal has been generated by the IC 555 timer. From the National instrument circuit design 12 (Multisim) software, we used a measurement probe for simulating the output results. Timer output when the variable capacitor is set at 25%.

Table 4: Output from the IC 555 timer

Parameter	Value
V	9V
V(P-P)	9V
V(rms)	7.05v

V(dc)	5.55v
I	5.65mA
I(P –P)	931mA
I(rms)	261mA
I(dc)	140mA
Frequency	7.09MH

Table 5: Final output at the Antenna

Parameter	Value
V	9.19V
V(P-P)	3.65V
V(rms)	9.0v
V(dc)	9.0v
I	9.19mA
I(P –P)	0mA
I(rms)	9.00mPA
I(dc)	9.00PA
Frequency	900MHz

4.1.2 Stage two

This stage is the RF-section of the system and the test result intended to obtain the final output frequency at the antenna. As in stage one, we use the same software (Multisim) measurement probe to produce the result in Figure 11.

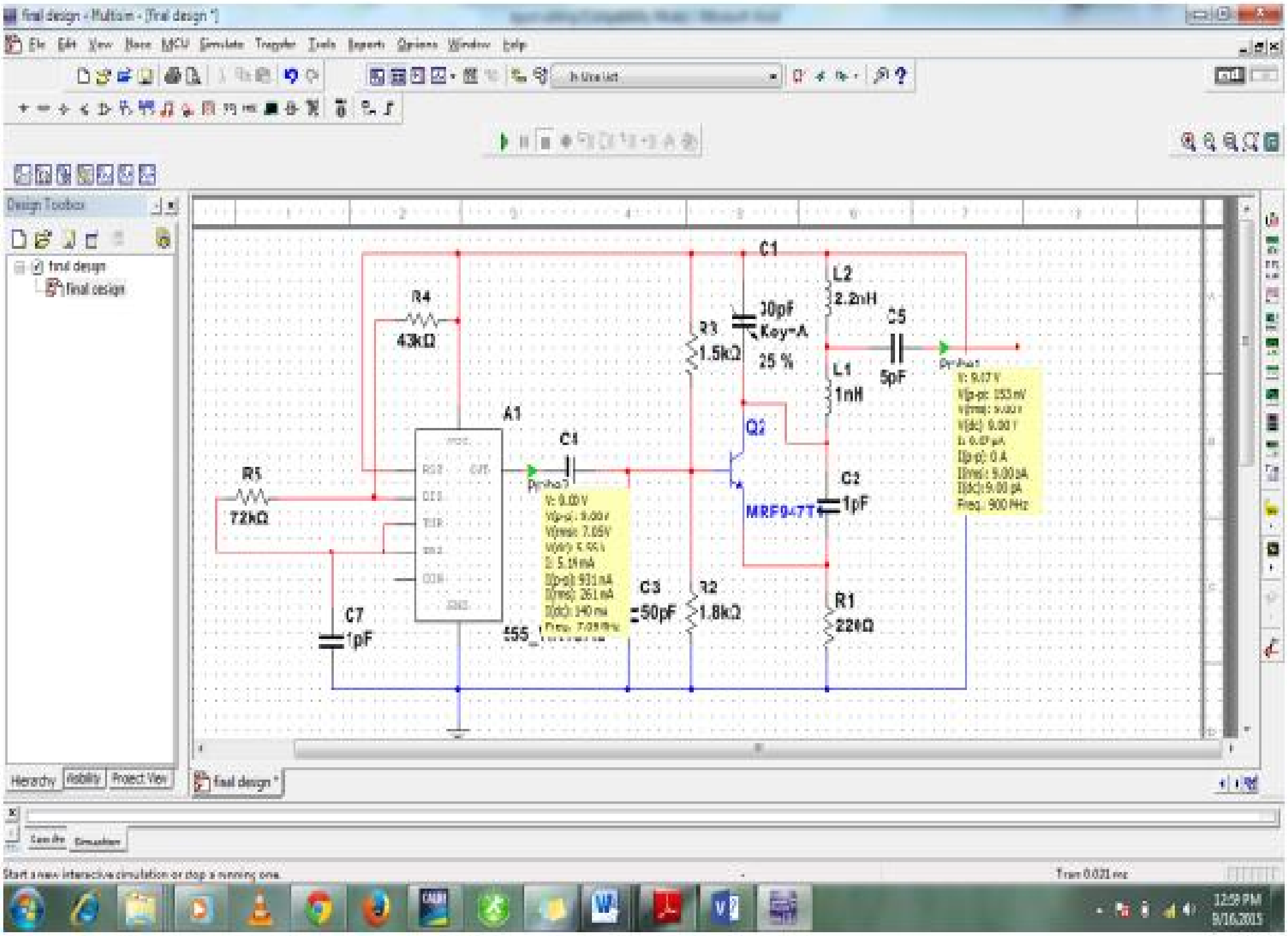

Figure 11: Screenshot of showing the output of the IC 555 and the antenna

4.2 Discussion

During the calculation for the value of the noise signal output from the 555 timer, the output frequency was 7.72MHz. The output from simulation was quite amazing since the 555 timer was able to generate a stable frequency known as a noise signal of 7.09MHz. This result deviates from the calculated result (7.09MHz) slightly. The deviation happened because the behavior of passive components at high frequency was not ideal. The frequency (7.09MHz) is far much lower than the required frequencies of around 900MHz. High frequency transistor (MRF974T1) which was able to amplify/boost the 7.09MHz (output) of the 555 timer up to around 1.2GHz.

The variable capacitor of 30pf was used to adjust the preferable range of this amplified frequency. Reduction of the percentage of variation, resulted to increase in the final output frequency and the higher the increase the percentage of variation the lower the final output frequency becomes. The preferable percentage value of the capacitor was at around 0% to 25%. That was because these percentage values of the capacitor give the output frequency values that are slightly below 900MHz and slightly above 900MHz hence covering the downlink transmission frequency of GSM 900.

5.0 CONCLUSION

The mobile phone communications has become one of the leading forms of communications with its ever growing technology. The 900MHz electromagnetic wave interference system provides a viable solution to prevent mobile phone usage during examinations. It is cost-effective, simple to implement, and suitable for localized deployment. This technology strengthens the security of exam environments and maintains academic integrity. Further work can involve integrating timers, remote control, or selective band interference to enhance flexibility and compliance with local regulations. The system was tested for functionality and the test results showed that the following were generated;

- A stable noise signal of 7.09MHz from the IF-section.
- A final output frequency that varies above and below 900MHz from the antenna.

This implies that the objective of generating a radio wave of the same frequency as that of the mobile phone operating in a GSM900 network has been achieved.

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