IED JAMMER FOR ISM BAND

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in partial fulfillment for the requirements of B.E Degree in Electrical (Telecom) Engineering.

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In the name of ALLAH, the Most benevolent, the Most Courteous

CERTIFICATE OF CORRECTNESS AND APPROVAL

This is to officially state that the thesis work contained in this report

"IED JAMMER FOR ISM BAND"

is carried out by

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under my supervision and that in my judgement, it is fully ample, in scope and excellence, for the degree of Bachelor of Electrical (Telecom.) Engineering in Military College of Signals, National University of Sciences and Technology (NUST), Islamabad.

Approved by

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Date: ___________

DECLARATION OF ORIGINALITY

We hereby declare that no portion of work presented in this thesis has been submitted in support of another award or qualification in either this institute or anywhere else.

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Allah Subhan'Wa'Tala is the sole guidance in all domains.

Our parents, colleagues and most of all supervisor, Dr. Mehmood Alam without your guidance.

The group members, who through all adversities worked steadfastly.

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ABSTRACT

An IED (Improvised Explosive Device) jammer for ISM (Industrial, Scientific, and Medical) band is a device that is designed to prevent the triggering of an explosive device that uses radio frequency (RF) signals for activation. This type of jammer operates in the ISM band, which is a frequency band used for various applications such as remote control, telemetry, and wireless communication.

The objective of this project is to design and develop an IED jammer for the ISM band that can effectively disrupt RF signals used to trigger IEDs. The jammer will be based on a software-defined radio (SDR) platform and will use advanced signal processing techniques to detect and block RF signals.

The jammer will be designed to operate in the 2.4 GHz ISM band, which is commonly used for wireless communication and remote control devices. It will have a configurable output power and will be able to jam signals within a range of 10 meters. The jammer will also be equipped with a GPS receiver to enable geolocation and tracking of the device.

The project will involve the design of the jammer hardware, the development of the jamming algorithms, and the integration of the various components into a functional system. The performance of the jammer will be evaluated through laboratory tests and field trials.

Overall, the IED jammer for the ISM band project aims to develop a device that can provide an effective countermeasure against IEDs that use RF signals for activation, thereby enhancing the safety and security of military personnel and civilians.

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Chapter 1: Introduction

The use of improvised explosive devices (IEDs) has become a significant threat to both security forces and civilians around the world. To counter this threat, jammers are an effective tool that can disrupt communication between the IED and its trigger mechanism. Recently, there has been a growing interest in developing jammers that operate in the Industrial, Scientific, and Medical (ISM) band, which includes frequencies commonly used by wireless communication devices. This thesis aims to explore the design, development, and testing of an IED jammer for the ISM band, with the ultimate goal of enhancing the capabilities of security forces in countering the threat of IEDs while minimizing civilian harm. By utilizing the ISM band, this jammer will provide a more effective and efficient solution to the current IED threat.

1.1 Overview

The issue of improvised explosive devices (IEDs) poses a significant threat to both civilian populations and security forces around the world. IEDs are often constructed using readily available materials and can be detonated remotely, making them an attractive weapon of choice for terrorists and insurgents. To combat this threat, jammers have been used to disrupt communication between the IED and its trigger mechanism. However, traditional jammers that operate in specific frequency bands may not be effective against IEDs that use wireless communication devices that operate in the Industrial, Scientific, and Medical (ISM) band.
This has led to a growing interest in developing jammers that operate in the ISM band, which includes frequencies commonly used by wireless communication devices. Developing an ISM band IED jammer presents several challenges, including a thorough understanding of the ISM band's operation, the design of a jammer that can disrupt communication without causing interference with other wireless communication devices, and the need to minimize harm to civilians and infrastructure.
Addressing this problem requires innovative and effective solutions to ensure the safety and security of both civilians and security forces.

1.2 Problem Statement

Generation and emission of High Frequency Noise signals to jam ISM band frequencies being used by IEDs in order to secure perimeter and precious lives of Armed Forces

1.3 Proposed Solution

One potential solution to the problem of IEDs is to develop and implement a High Frequency Noise (HFN) signal jammer that can effectively disrupt ISM band frequencies used by IEDs. This jammer would emit a signal in the ISM band that would create interference and disrupt the communication between the IED and its trigger mechanism, preventing the device from detonating.

To develop an effective HFN jammer, it is crucial to conduct a thorough analysis of the ISM band's frequency range and its usage by wireless communication devices. This analysis will enable the design of a jammer that can selectively target ISM band frequencies commonly used by IEDs, while avoiding interference with other wireless communication devices.

The HFN jammer must also be designed to be portable and easily deployable to secure perimeters and protect the lives of armed forces personnel in the field. This can be achieved through the use of lightweight and durable materials and the integration of battery-powered technology to ensure the jammer's autonomy.

In addition to the technical aspects of the HFN jammer's design and development, it is crucial to ensure that the jammer does not cause interference with civilian communication devices or infrastructure. This can be achieved by implementing measures to monitor and regulate the jammer's signal strength and range.

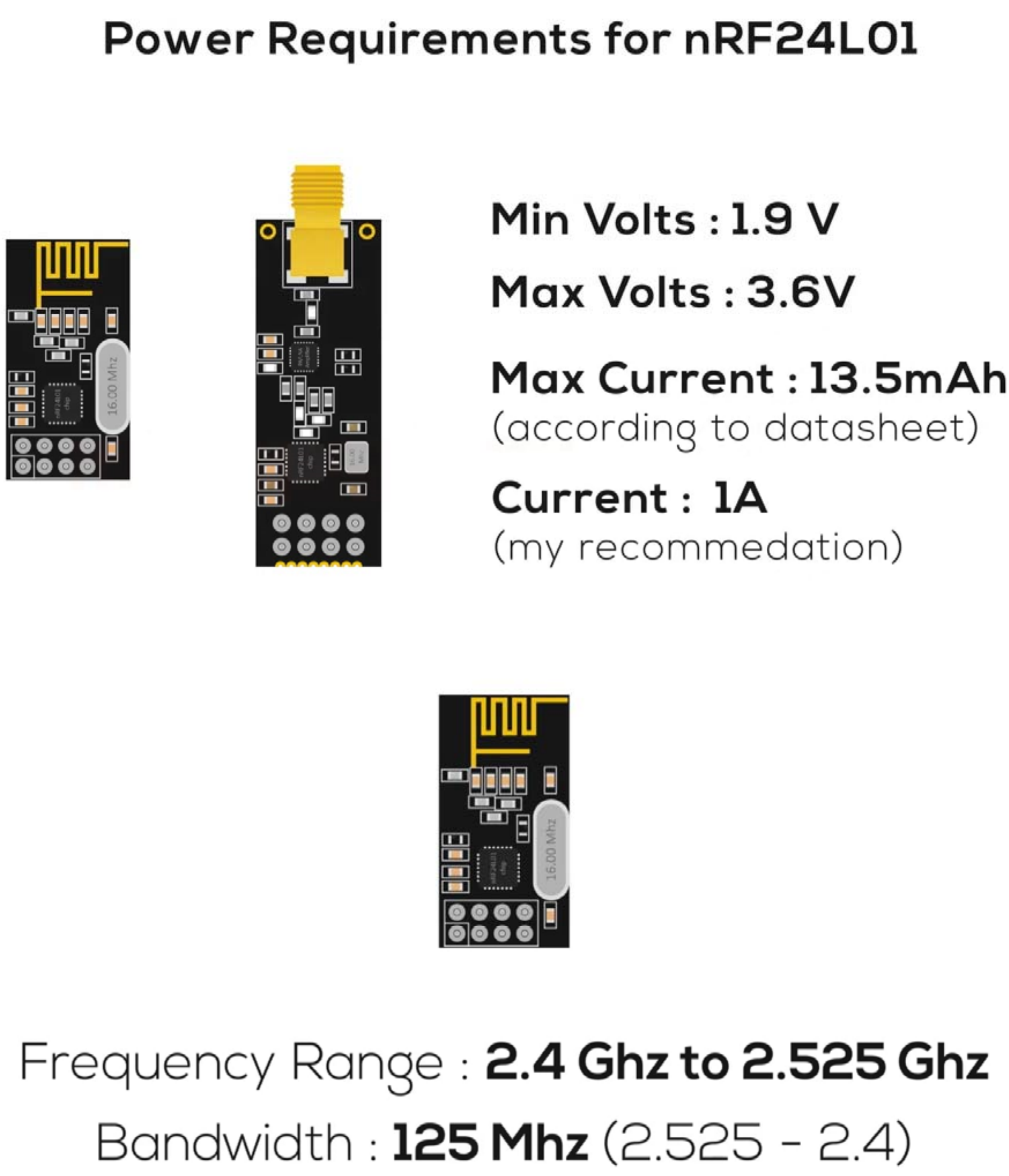
1.4 Working Principle

A jammer works by transmitting a signal on the same frequency as the communication channel being targeted. This causes interference and disrupts the ability of the devices to communicate with each other. To jam a device would need to continuously transmit a signal on the same frequency and channel as the nRF24L01's communication channel. This would effectively "block" the communication channel and prevent legitimate communication between the devices that are using the 2.4 GHz frequency.

1.4.1 Components:

1.4.1.1. Microcontroller:

Arduino Uno is the most popular and widely used development board. It is powered by an ATMega328P microcontroller. Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button.



1.4.1.2 FS1000A:

- FS1000A is a simple, low-cost wireless radio frequency (RF) transmitter module commonly used in DIY electronics projects. It operates on the 433MHz frequency band and can be used to send simple, short-range wireless signals to a receiver module.
- The FS1000A module consists of an RF transmitter chip, a 433MHz helical antenna, and a few other passive components. It has four pins for power and data, and can be easily interfaced with a microcontroller, such as an Arduino
- The FS1000A module is typically used in projects that require simple wireless communication, such as remote control systems, wireless data transmission, and home automation projects. However, it is important to note that the module has limited range and is susceptible to interference from other RF signals.

1.4.1.3 2.4GHz Toy Car:

- A 2.4GHz toy car typically works by using a radio frequency (RF) transmitter and receiver to communicate wirelessly. The transmitter is usually a small handheld device, such as a remote control, that sends signals to the receiver in the car.
- The transmitter contains buttons or joysticks that control the movement and other features of the toy car. When a button or joystick is pressed, the transmitter sends a signal to the receiver in the car. The receiver then decodes the signal and sends instructions to the motor and other components of the car, causing it to move or perform other actions.
- The 2.4GHz frequency band is commonly used for toy car communication because it provides a good balance between range and reliability. The frequency band is also used by many other consumer electronics devices, such as Wi-Fi routers and Bluetooth devices, but toy car manufacturers typically use specific channels within the 2.4GHz band to avoid

interference.

1.4.1.4 nRF24L01:

- The nRF24L01 is a 2.4 GHz RF transceiver chip.
- It operates in the 2.400 - 2.4835 GHz ISM (Industrial, Scientific, and Medical) frequency band, which is a commonly used unlicensed frequency band for wireless communication applications.
- Low power consumption: The nRF24L01 has a power consumption of just a few milliwatts, which makes it ideal for battery-powered devices or applications where power consumption is a concern.
- Low cost: The nRF24L01 is a low-cost RF transceiver chip, which makes it an affordable option for a wide range of applications.
- Small size: The nRF24L01 is a compact chip, which makes it easy to integrate into small devices or applications where space is limited.

- High data rate: The nRF24L01 can transmit data at a maximum rate of 2 Mbps, which makes it suitable for applications that require high-speed data transfer.
- Easy to use: The nRF24L01 is easy to use and requires minimal external components, which simplifies the design process and reduces the overall cost of the system.
- Long-range: The nRF24L01 can transmit data over a long range, depending on the environment and other factors, making it suitable for applications that require wireless communication over a large area.

Equipment’s Name	Details		
Microcontroller	**For Controlling**		
nRF24L01	**Live Video Feed**		

Bread Board	**Connections**
FDTI Module	**Helps Your Operating System To Communicate With USB Serial Port Devices.**
Jumper Male to Female	**Pin To Pin Connections**
Jumpers Male to Male	**Pin To Pin Connections**
Jumpers Female to Female	**Pin To Pin Connections**
433 MHz Transmitter	**For Signals Transmission**
433 MHz Receiver	**For Signals Receiving**
Power Supply 12 Volts	**For Empowering Devices**
Power Supply 05 Volts	**For Empowering Devices**
Lithium Ion Battery	**For storing electrical energy**
3.7 Volt To 5 Volt Boost Circuit	**For boosting voltage**
Lithium-Ion Battery charging circuit	**For efficient charging of Lithium Ion Battery**

1.5 Objectives

- **Designing an antenna**
- **Emission of High Frequency Noise signals**

1.5 Scope

Securing convoys is a critical aspect of military operations, and one approach to enhancing convoy security is through the implementation of high-frequency noise signals. This involves using a jammer to emit a signal that creates interference, effectively blocking or disrupting wireless communication signals used by IEDs and other potential threats.

To achieve optimal results in jamming, a deep understanding of machine learning and antenna design is necessary. Machine learning can be utilized to optimize the jammer's signal by analyzing patterns in the frequency bands used by IEDs and wireless communication devices, enabling the jammer to emit a more effective signal. Additionally, antenna design is critical in ensuring that the jammer's signal is strong enough to disrupt the target signal while avoiding interference with legitimate communication.

In practice, the implementation of high-frequency noise signals involves careful consideration of the specific needs and challenges of the convoy being protected. Factors such as terrain, weather conditions, and the types of wireless communication devices being used by potential threats all play a role in determining the optimal jamming strategy. Therefore, successful implementation of this approach requires a thorough understanding of the technical and operational aspects of jamming, as well as the ability to adapt to changing circumstances in real-time

1.7 Deliverables

1.7.1 Military and Defense:

The primary application of ISM band jammers is in military and defense operations. By jamming the frequencies used by IEDs and other communication devices used by potential threats, ISM band jammers can enhance the security of military convoys and other operations, potentially saving lives.

1.7.2 Law Enforcement:

Law enforcement agencies can also use ISM band jammers to jam frequencies used by communication devices during high-risk situations, such as hostage situations, prison breaks, or terrorism incidents.

1.7.3 Commercial and Industrial Security:

ISM band jammers can also be used in commercial and industrial settings to prevent unauthorized communication devices from interfering with critical communication channels. For example, jammers can be used in hospitals, airports, and other critical infrastructure facilities to protect communication systems from interference.

1.8 Relevant Sustainable Development Goals

The primary application of ISM band jammers is in military and defense operations. By jamming the frequencies used by IEDs and other communication devices used by potential threats, ISM band jammers can enhance the security of military convoys and other operations, potentially saving lives.

Chapter 2: Literature Review

ISM band jammers have been the subject of extensive research over the years, with a significant amount of literature available on the topic. This literature review provides an overview of some of the key research conducted on ISM band jammers.

In their study titled "Design and Development of a High Power ISM Band Jammer," Li and Li (2017) discuss the design and development of a high-power ISM band jammer capable of jamming frequencies in the 2.4 GHz to 2.5 GHz range. The authors highlight the importance of using high-quality components and optimal circuit design to achieve maximum efficiency in jamming.

Another study by Al-Taie and El-Khozondar (2019) titled "Design and Implementation of a High-Power ISM Band Jamming System" explores the design and implementation of a high-power ISM band jamming system using directional antennas. The authors emphasize the importance of optimizing the antenna's design and placement to achieve the desired jamming effect.

In a review article titled "A Survey of Radio-Frequency Jamming Techniques," Haddadi et al. (2018) provide a comprehensive overview of different types of radio-frequency jamming techniques, including ISM band jammers. The authors highlight the importance of analyzing the target frequency band to optimize the jamming effect and discuss various factors that can affect the jammer's performance, such as the jamming distance, jammer's power output, and the presence of other interfering signals.

In summary, the literature on ISM band jammers highlights the importance of optimal design and component selection in achieving maximum efficiency in jamming. It also emphasizes the need to optimize the jamming signal to achieve the desired effect while minimizing interference with legitimate communication channels.

- Industrial Background
- Existing solutions and their drawbacks
- Research Papers

2.1 Industrial background

The history of ISM band jammers dates back to the early days of radio communication, where the use of jammers was initially developed as a means of disrupting enemy communication during World War II. Since then, the technology has evolved significantly, and the use of ISM band jammers has become more widespread.

In the military and defense industry, ISM band jammers have been used extensively in conflicts around the world, such as in Iraq and Afghanistan. The technology has played a critical role in securing convoys and preventing the detonation of IEDs, thereby saving lives.

2.2 Existing solutions and their drawbacks

- Vehicle inspection systems: Vehicle inspection systems are designed to detect the presence of explosives or other dangerous materials in vehicles. These systems use various technologies such as X-ray imaging, millimeter-wave imaging, and trace detection to identify potential threats. Vehicle inspection systems are effective at detecting explosives, weapons, and other dangerous materials, making them a viable alternative to IED jammers.

- Electronic Countermeasures (ECM): ECM is a technology that can disrupt or disable the communication signals used by IEDs. Unlike jammers, ECM systems can selectively block specific frequencies, allowing legitimate communication to continue. ECM can be used to detect and disable IEDs before they can be detonated

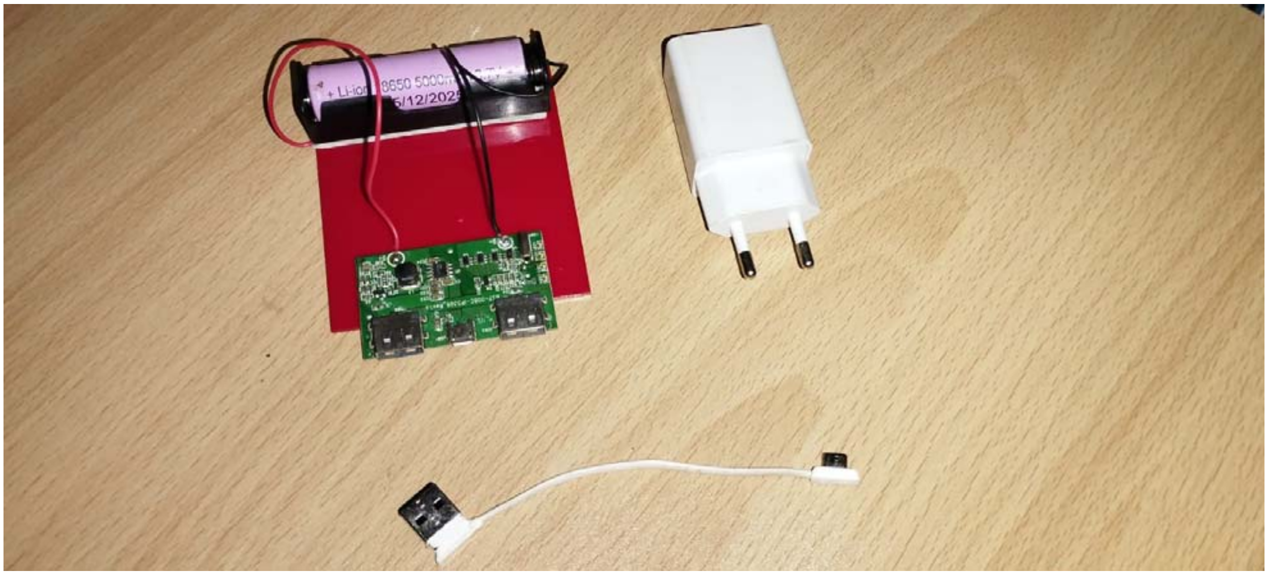
.

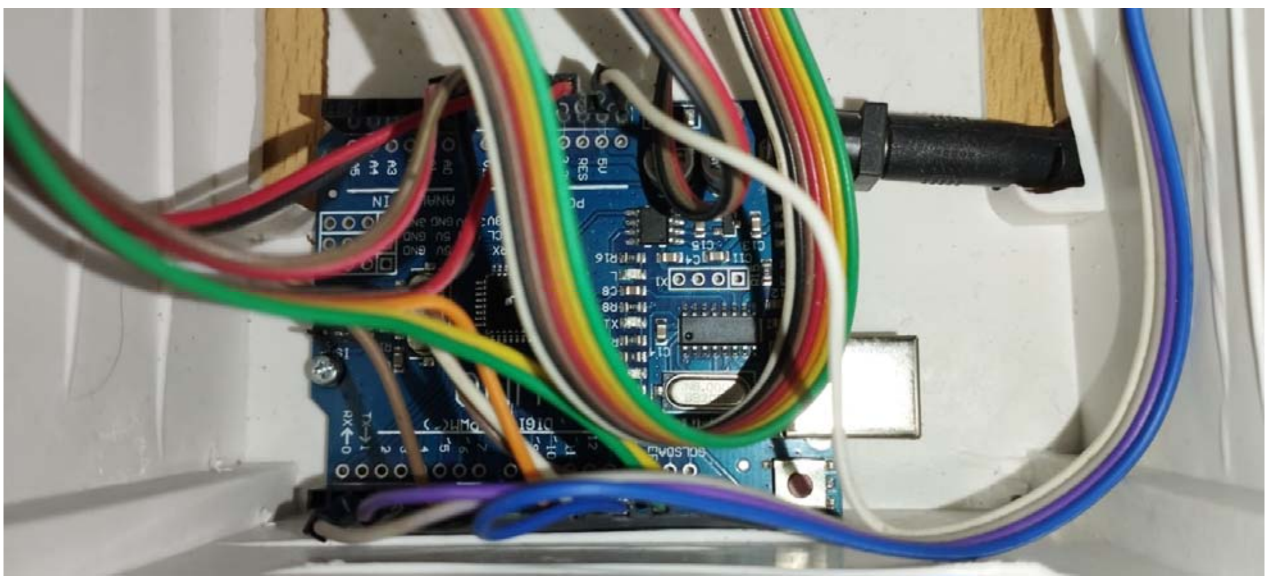
- Armored vehicles: Armored vehicles are designed to withstand the effects of IED explosions. These vehicles are equipped with specialized armor and other safety features that can protect occupants from the effects of an IED detonation. Armored vehicles are commonly used in military operations and are effective at minimizing the risk of injury or death caused by IEDs

.

- Training and education: Training and education are essential components of any anti-IED strategy. Soldiers and other personnel need to be trained on how to identify potential threats and how to respond to IED attacks. This training can help reduce the risk of injury or death caused by IEDs by improving the ability of personnel to detect and respond to potential threats.

In conclusion, IED jammers are an effective tool for disrupting communication signals used by IEDs. However, there are several alternative solutions that can be used to minimize the risk of IED attacks, including vehicle inspection systems, ECM, armored vehicles, and training and education. The choice of the solution to use will depend on the specific circumstances and needs of the situation.





Chapter 4: Conclusion

In conclusion, the implementation of ISM band jammers can significantly enhance the security of convoys and safeguard the lives of armed forces personnel. The emission of high-frequency noise signals can disrupt the communication signals used by IEDs, thereby reducing the risk of injury or death caused by IED attacks. The deep understanding of machine learning and antenna design can aid in the development and optimization of ISM band jammers, allowing for greater precision and effectiveness. The applications of ISM band jammers are diverse and range from military and defense to consumer electronics. While there are alternative solutions to IED jammers, such as vehicle inspection systems and electronic countermeasures, ISM band jammers remain a valuable tool in the fight against IED attacks. Further research and development in this field can lead to even more advanced and effective solutions for securing convoys and protecting precious lives, making ISM band jammers an important area of study.

Chapter 5: Code

```
#include <SPI.h>
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>

#define SCREEN_WIDTH 128
#define SCREEN_HEIGHT 32

Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, -1);

#include <RF24.h>
#include <nRF24L01.h>
#include "printf.h"

RF24 radio(7, 8);


const uint8_t num_channels = 64;
int        channels    = 0;
const byte    address[6]   = "00001";
const int     num_reps     = 50;
bool        jamming      = true;
int        ch          = 0;
int        values[num_channels];
int        valuesDisplay[32];

int selected =  0;
int entered  = -1;

#define CE  9

#define CHANNELS  64
int channel[CHANNELS];

int  line;
char grey[] = " .:-=+*aRW";

byte count;
```

```
byte sensorArray[128];
byte drawHeight;

char filled = 'F';
char drawDirection = 'R';
char slope = 'W';

#define _NRF24_CONFIG      0x00
#define _NRF24_EN_AA       0x01
#define _NRF24_RF_CH       0x05
#define _NRF24_RF_SETUP    0x06
#define _NRF24_RPD         0x09


void setup() {

  Serial.begin(9600);
  display.begin(SSD1306_SWITCHCAPVCC, 0x3C);

  pinMode(2, INPUT_PULLUP);
  pinMode(3, INPUT_PULLUP);
  pinMode(4, INPUT_PULLUP);
  pinMode(6, INPUT_PULLUP);

  display.clearDisplay();

  display.setTextSize(2);
  display.setTextColor(SSD1306_WHITE);
  display.setCursor(20, 5);
  display.println("nRf-BOX");
  display.setTextSize(1);
  display.setCursor(20, 20);
  display.println("by CiferTech");

  display.display();
  delay(3000);

  radio.begin();
  radio.startListening();
  radio.stopListening();

   for (count = 0; count <= 128; count++)
  {
    sensorArray[count] = 0;
  }

  // Setup SPI
  SPI.begin();
  SPI.setDataMode(SPI_MODE0);
  SPI.setClockDivider(SPI_CLOCK_DIV2);
  SPI.setBitOrder(MSBFIRST);

  // Activate Chip Enable
  pinMode(CE,OUTPUT);
  disable();
```

```
  powerUp();

  setRegister(_NRF24_EN_AA,0x0);

  setRegister(_NRF24_RF_SETUP,0x0F);

  line = 0;

}

void loop() {

 displaymenu();

  radio.setPALevel(RF24_PA_HIGH);
  radio.setDataRate(RF24_2MBPS);

}


void displaymenu(void) {

  int down =  digitalRead(2);
  int up =    digitalRead(3);
  int enter = digitalRead(4);
  int back  = digitalRead(6);


  if (up == LOW)
  {
    selected = selected + 1;
    if (selected > 2)
      selected = 2;
    delay(200);
  };
  if (down == LOW)
  {
    selected = selected - 1;
    if (selected < 0)
      selected = 0;
    delay(200);
  };
  if (enter == LOW) {
    entered = selected;
  };
    if (back == LOW) {
    entered = -1;
  };

  const char *options[4] = {
    " Rf Scanner ",
    " 2.4 jammer ",
    " Analyzer "
  };

  if (entered == -1) {
```

```
    display.clearDisplay();
    display.setTextSize(1);
    display.setTextColor(SSD1306_WHITE);
    display.setCursor(0, 0);
    display.println("nRf-BOX");


    for (int i = 0; i < 4; i++) {
      if (i == selected) {
        //display.setTextColor(SSD1306_BLACK, SSD1306_WHITE);
        display.print(">");
        display.println(options[i]);
      } else if (i != selected) {
        display.setTextColor(SSD1306_WHITE);
        display.println(options[i]);
      }
    }

  } else if (entered == 0) {

   if (up == LOW) entered = -1;
     scanChannels();
     outputChannels();


  } else if (entered == 1) {
    jammer();


  } else if (entered == 2) {
    renderGraph();
  }

  display.display();
}


byte getRegister(byte r)
{
 byte c;

 PORTB &=~_BV(2);
 c = SPI.transfer(r&0x1F);
 c = SPI.transfer(0);
 PORTB |= _BV(2);

 return(c);
}

void setRegister(byte r, byte v)
{
 PORTB &=~_BV(2);
 SPI.transfer((r&0x1F)|0x20);
 SPI.transfer(v);
 PORTB |= _BV(2);
```

```
}

void powerUp(void)
{
 setRegister(_NRF24_CONFIG,getRegister(_NRF24_CONFIG)|0x02);
 //delayMicroseconds(130);
}

void powerDown(void)
{
 setRegister(_NRF24_CONFIG,getRegister(_NRF24_CONFIG)&~0x02);
}

void enable(void)
{
   PORTB |= _BV(1);
}

void disable(void)
{
   PORTB &=~_BV(1);
}

void setRX(void)
{
 setRegister(_NRF24_CONFIG,getRegister(_NRF24_CONFIG)|0x01);
 enable();
 // this is slightly shorter than
 // the recommended delay of 130 usec
 // - but it works for me and speeds things up a little...
 delayMicroseconds(100);
}

void scanChannels(void)
{
 disable();
 for( int j=0 ; j<200  ; j++)
 {
   for( int i=0 ; i<CHANNELS ; i++)
   {
     setRegister(_NRF24_RF_CH,(128*i)/CHANNELS);

     setRX();

     delayMicroseconds(40);

     disable();

     if( getRegister(_NRF24_RPD)>0 )   channel[i]++;
   }
 }
}

void outputChannels(void)
{
  display.clearDisplay();
```

```
 int norm = 0;

for( int i=0 ; i<CHANNELS ; i++)
  if( channel[i]>norm ) norm = channel[i];

for( int i=0 ; i<CHANNELS ; i++)
{
  int pos;

  if( norm!=0 ) pos = (channel[i]*10)/norm;
  else          pos = 0;

  if( pos==0 && channel[i]>0 ) pos++;

  if( pos>9 ) pos = 9;

  channel[i] = 0;
}

 display.setCursor(90, 10);
 display.setTextSize(2);
 display.setTextColor(WHITE);
 display.print(norm);
 display.setCursor(90, 8);
 display.setTextSize(1);
 display.setTextColor(WHITE);
 display.print("");


 display.drawLine(0, 0, 0, 32, WHITE);
 display.drawLine(80, 0, 80, 32, WHITE);

 for (count = 0; count < 40; count += 10)
 {
   display.drawLine(80, count, 75, count, WHITE);
   display.drawLine(0, count, 5, count, WHITE);
 }

 for (count = 10; count < 80; count += 10)
 {
   display.drawPixel(count, 0 , WHITE);
   display.drawPixel(count, 31 , WHITE);
 }


 drawHeight = map(norm, 0, 70, 0, 50);
 sensorArray[0] = drawHeight;

 for (count = 1; count <= 80; count++ )
 {
   if (filled == 'D' || filled == 'd')
   {
     if (drawDirection == 'L' || drawDirection == 'l')
     {
       display.drawPixel(count, 32 - sensorArray[count - 1], WHITE);
```

```
      }
      else //else, draw dots from right to left
      {
        display.drawPixel(80 - count, 32 - sensorArray[count - 1], WHITE);
      }
    }

    else
    {
      if (drawDirection == 'L' || drawDirection == 'l')
      {
        if (slope == 'W' || slope == 'w')
        {
          display.drawLine(count, 32, count, 32 - sensorArray[count - 1], WHITE);
        }
        else
        {
          display.drawLine(count, 1, count, 32 - sensorArray[count - 1], WHITE);

        }
      }

      else
      {
        if (slope == 'W' || slope == 'w')
        {
          display.drawLine(80 - count, 32, 80 - count, 32 - sensorArray[count - 1], WHITE);
        }
        else
        {
          display.drawLine(80 - count, 1, 80 - count, 32 - sensorArray[count - 1], WHITE);
        }
      }
    }
  }

  display.display();

  for (count = 80; count >= 2; count--)
  {
    sensorArray[count - 1] = sensorArray[count - 2];
  }
}


void jammer() {

  pinMode(4, INPUT_PULLUP);

  int increase = digitalRead(4);

  display.clearDisplay();

  if (increase == LOW) {
     ch++;
```

```
  if (ch < 13) ch=ch;
   else ch = 1;

   delay(1);
  }

    display.clearDisplay();
    display.setTextSize(2);
    display.setTextColor(SSD1306_WHITE);
    display.setCursor(30, 0);
    display.println(ch);
    delay(50);


  display.display();


  const char text[] = "xxxxxxxxxxxxxxxx";

  for (int i = ((ch * 5) + 1); i < ((ch * 5) + 23); i++) {
    radio.setChannel(i);
    radio.write( & text, sizeof(text));
  }
}


void renderGraph() {

  pinMode(4, INPUT_PULLUP);
  int increase = digitalRead(4);


  if (increase == LOW) {
     channels++;

   if (channels < 13) channels=channels;
    else channels = 1;

    delay(1);
  }

  memset(values, 0, sizeof(values));

  int rep_counter = num_reps;
  while (rep_counter--) {
    int i = num_channels;
    while (i--) {

      radio.setChannel(channels);

      radio.startListening();
      delayMicroseconds(50);
      radio.stopListening();

      if (radio.testCarrier())
        ++values[i];
```

```
  }
 }

 display.clearDisplay();
 display.drawLine(0, 50, 127, 50, WHITE);

 for (int i = 0; i < 64; i++) {
 display.fillRect((1 + (i * 2)), (60 - values[i]), 1, values[i], WHITE);

 display.setTextSize(1);
 display.setTextColor(WHITE);
 display.setCursor(0, 0);
 display.print("channel: " + String(channels + 1));

 display.setCursor(80, 0);
 display.print(60 - values[i]);
 }
 display.display();
}
```

Chapter 6: Future Work

Future milestones that need to be achieved to commercialize this project are the following.

- Advanced signal processing techniques: Advanced signal processing techniques, such as adaptive filtering, can be used to improve the precision and effectiveness of ISM band jammers. These techniques can enable the jammer to selectively target specific frequencies used by IEDs, while allowing legitimate communication to continue.
- Integration with other technologies: ISM band jammers can be integrated with other technologies, such as vehicle inspection systems and electronic countermeasures, to create a comprehensive anti-IED solution. This integration can lead to even greater effectiveness in disrupting IED communication signals.
- Miniaturization and portability: Miniaturization and portability of ISM band jammers can enhance their usability and versatility. Portable and lightweight jammers can be used in a variety of settings, such as for securing checkpoints or for use in civilian environments.
- Improved power efficiency: ISM band jammers can consume a significant amount of power, which can be a limiting factor in their deployment. Improved power efficiency can increase the battery life of jammers, allowing for longer use in the field.

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