Radio Audio Gateway

(RAG)

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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

"Radio Audio Gateway"

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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 Engineering in Military College of Signals, National University of Sciences and Technology (NUST), Islamabad.

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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, Muhammad Junaid Khan

Without your guidance, the group members, who through all adversities worked steadfastly.

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ABSTRACT

Radio incompatibility is one of the major issues in the present-day world. In the modern world where radio communication is a significant source used for communicating let it be Law Enforcing Agencies (LEAs), airport security and traffic control, mega-development & exploration agencies, police, firefighters, medical services and transportation, disaster management, ambulances. In order for these authorities to function efficiently during times of emergencies or disasters, when mobile telecom services are not available, the only mean of communication for different agencies is radio. Therefore, radio incompatibility cannot be ignored. The aim of this project is to design and implement an indigenous gateway for the audio interoperability of radios from different OEMs (Original Equipment Manufacturers) that is user-friendly and cost-efficient. It works using a voice-activated switch (VOX) for the detection of the voice signal. The message or voice signal from the radio operating at the different net is given as input to the gateway. The signal is processed and transmitted to a radio operating at a different net.

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ABBREVIATIONS:

Technical Terms:

PTT	Push To Talk
VOX	Voice Activated Switch
RFU	Reserved for Future Use
OEMs	Original Equipment Manufacturers

Radios:

LMR	Land Mobile Radio
SPR	Secure Personal Radio
SDR	Software Defined Radio

Chapter 1: Introduction

1.1 Overview

The invention of radio communication dates to the late 19th century, when researchers first started looking into the characteristics of electromagnetic radiation. Radio communication was initially primarily used for ship-to-shore communication. Amateur radio enthusiasts also used it for communication and experimentation. Radio technology continued to advance in the decades that followed, with the creation of stronger transmitters and more perceptive receivers. In fact, radio communication was essential during both World Wars I and II. Radio communication has a broad range of applications, from business and military use to personal communication. Some of the most typical applications are listed below:

- One of the earliest and most well-known uses of radio communication is **radio broadcasting**. Radio stations transmit a variety of content to listeners all over the world, including music, sports, and news.
- Radios are frequently used for **two-way communication**, such as between an air traffic controller and a pilot or between emergency personnel and dispatchers.
- The Global Positioning System (GPS) used for **navigation**, which uses radio signals from satellites to pinpoint a user's location, uses radio communication to navigate.
- Radio communication is a vital part of **military** operations, from communication between soldiers on the ground to communication between aircraft and command centers.

Today's world is a world of digitalization. In general, radio communication is a flexible technology with a wide range of uses in the modern era.

With the progress in technology many different radio OEMs are present in the market each with different functionalities, each better than the previous one. Due to the multiple radios

manufacturers, the radios are incompatible with the radio of different OEM. Therefore, radio interoperability cannot be ignored.

The ability of various radio systems and networks to communicate with one another, even when they are utilizing various frequencies, protocols, or technologies, is termed as radio interoperability. Insufficient radio interoperability has been criticized in several incidents for communication breakdowns and other problems in emergency situations. Here are a few illustrations:

- **9/11 Attack**: Multiple departments, including the police and fire departments, experienced communication breakdowns during the September 11th attacks in New York City. Response efforts were hampered because the various agencies were using various radio systems and could not effectively communicate with one another.
- **California Wildfire**: Communication breakdowns occurred between various agencies, few of which are fire departments, law enforcement, and emergency medical services, during the wildfires that ravaged California in 2017. Response efforts were hampered because the various agencies were using various radio systems and could not effectively communicate with one another.

These incidents serve as a reminder of the value of radio interoperability in emergency situations and the necessity for agencies to have reliable communication systems in place to ensure efficient coordination and response.

1.2 Problem Statement

Day to day incidents demonstrate that there is a need for seamless communications among the first responder team, police, fire, medical services, transportation and Law Enforcing Agencies. The afore cited organizations in most cases are unable to adequately communicate with one another due to following reasons:

- Different organizations use radios of varying OEMs (iCOM, Harris, Aselsan etc.)
- Radios by different OEMs use different waveforms, frequencies, bands, channels etc. resultantly Radio nets of varying manufacturers don't inter-communicate.
- Additionally varying range of different radios also needs to be catered for.

1.3 Proposed Solution

There can be multiple solution to this problem but each with its own problem. One solution is to buy new similar radio sets for all the organizations, which would bear a very hefty cost. Another solution can be obtaining professional gateways but being not indigenous, they are not reliable and are very expensive.

The proposed solution to the problem is development of indigenous Audio gateway.

Using audio gateway different radio sets operating at different frequencies, waveforms, bands etc. will be able to communicate with each other easily. The proposed solution will integrate radio nets of different organizations mentioned earlier irrespective of the type of radios being used by them. This solution focuses only on audio transmission, so it'll be very cost effective. Being indigenously built, it will not pose any risk of breach of security.

1.4 Objectives

- Our most important objective of the project is to provide low-cost and secure indigenous audio gateway, so that it is affordable even if required in bulk.
- To make user friendly, Gateway, which focuses only on audio feature, as other Gateways provide many extra features which are not required and makes them difficult to be used in the field.
- Security of communication will be ensured as it will be an indigenous device and no third party will be involved in manufacturing.

- To make a Final Product ready to be deployed in field and industry.

1.5 Scope

This project finds its scope at various organizations such as Law enforcing agencies (LEAs), airport security and traffic control, mega development & exploration agencies, police, firefighters, medical services and transportation, disaster management, ambulances and many more. During the times of emergencies or disasters, when the mobile telecom services are not available, only mean of communication for different agencies is radio and incompatibility can be an issue.

With the incorporation of gateway in their radio nets, these organizations would be able to:

- Communicate with each other while operating their own unique radio nets.
- Utilize radio sets of different OEMs within the same organization.

This will ensure better coordination/ synergy and save a lot of budget.

1.6 Deliverables

1.6.1 Audio Gateway:

It is the product that interoperable radios of different OEMs. The radios operating at different frequencies and waveforms, once connected, can receive and transmit to each other networks.

1.6.2 Connecting Cables:

Cables are designed according to the pin configuration of the radio. Each radio has its own features thus different pin configuration. The cables have radio connector at one end and easily available ethernet connector at the other end.

1.6.3 Product Manual:

It provides the description about the product. Its working, use and connector details.

1.7 Relevant Sustainable Development Goals

- **Industry Innovation and Infrastructure.**

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

What is the Locally Relevant Socio-Economic Issue that the Project Addresses?

Integration of different radio nets is one of the major issues faced by organizations (especially law enforcement agencies) using radios of different companies. Professional gateways are hard to procure and are very costly. This project will lead to availability of efficient and low-cost Local radio gateway.

1.8 Structure of Thesis

Chapter 2 describes the literature review, background, and analysis study of this thesis.

Chapter 3 contains the basic introduction about the used tactical radios.

Chapter 4 elaborates the design and development of the voice activated switch.

Chapter 5 shows the design and development of the audio gateway.

Chapter 6 highlights the product specifications.

Chapter 7 sums up by describing the conclusion of the project.

Chapter 8 highlights the future work that can be done further on this project.

Chapter 2: Literature Review

To launch a new product, the features of similar products that have already been released are modified and improved. A literature review is a crucial step in the process of turning an idea into a new product. Likewise, a thorough analysis of all similar projects is required for the development of a product and its replacement in relation to the traffic system. We divided our research into the following categories:

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

2.1 Industrial background

Interoperability is one of the main problems in radio communication, and it has caused many other issues as discussed in the problem statement, which increases the need for an audio gateway. Thus, creation of a sizable market for industrial growth.

Audio gateways can be traced back to the early days of audio technology when analogue cables and connectors were used to transmit audio signals. Audio gateways were created as audio technology advanced to provide an interface between radio devices. In the 1990s, as digital audio technology advanced and made it possible for audio signals to be transmitted more effectively and reliably, the use of audio gateways increased in a variety of industrial settings, such as sound reinforcement systems, recording studios, broadcasting.

facilities, and live events. In the automotive industry, they are used for in-car entertainment systems, and in the telecommunications industry, they are used for voice-over-IP (VoIP) systems. Therefore, resulting in increase in industrial growth.

Audio gateways are likely to become more advanced as technology advances, with support for new digital audio standards and protocols, as well as more advanced processing capabilities.

2.2 Existing solutions and their drawbacks

There are numerous audio gateway products on the market today, each customized to specific needs and requirements but with few drawbacks accordingly:

- Many of these gateways include a lot of features (such as VoIP channels, remote web page management, SIP compatibility, Operating systems) which may not be necessary if the core objective is to transmit voice only.
- Professional gateways procured from international market are very costly (price ranging in millions).
- Security risks are also involved. Confidentiality is also at risk when we are communicating over IP.

The following table shows the data about existing audio gateways. Each gateway has multiple features according to the need but with these extra features the cost of gateways also increases as well as other drawbacks afore cited can be noticed.

NAMES		SYTECH			NICEUC					ORION		REDCOM SIGMA	ICOM	CUBIC
	iPTT Radio Gateway	Radius 4 Port	RIOS Tac 2	Radius 2U	NC-MG221	NC-MG232A/R	NC-MG320A/R	NC-MG640A/R	NC-MG930A/R	RIP 1	RIP COMPLEX	XRI - 400	VE-PG2	Vocality RoIP
chargeable			YES											
Audio/Radio/PTT ports		4		16	1 to 2	4/1 to 8	1 to 4	8/4 to 16	16 to 48	2	4 or 8	4	3	12
VoIP channels					16	32 or 16	64 or 128	32 or 64	64 or 128					
water resistant	YES	YES												
rack mountable				YES	YES, 1U Height	YES, 1U Height	YES, 1U Height	YES, 2U Height	YES, 3.5U Height	19" rack, 2RU high, 17 RIP's per shelf	19" Rack			9" Rack
Echo cancellation / Noise Suppression	YES				YES	YES	YES	YES	YES	YES	YES	YES		YES
CNG (Comfort noise generation)					YES	YES	YES	YES	YES					

Gain control					YES	YES	YES	YES	YES			YES, Software based		YES [Gain ip= -12 to +55, op= -57 to +6 dBs]
remote web page management		YES		YES	YES	YES	YES	YES	YES	YES	YES		YES	
wired and wireless comm					YES	YES	YES	YES	YES	YES	YES			
SIP compatibility		Smartphone		Smartphones	Huawei, CISCO,ZTE, etc	Huawei, CISCO,ZTE, etc	Huawei, CISCO,ZTE, etc	Huawei, CISCO,ZTE, etc	Huawei, CISCO,ZTE, etc	YES	YES	YES		YES
Input Voltage	7.4V DC	12V DC		9-15V DC	AC voltage 110 - 240	DC 48V, AC 110 to 240 volts	DC 48V, AC 110 to 240 volts	AC 110 to 240 volts	DC 48V, AC 110 to 240 volts	100 to 250 V AC, 12-24v DC	100 to 250 VAC, 12v DC nominal	10–26 VDC	12 V DC +- 10%	5-35 V DC
Power		12W		70W	25W	40W	40W	50W	100W	5W	30W	30W		5W
Weight	250 g	3.4 kg	18.14 kg	5 kg	3 kg	4.5kg	4.5kg	5.5kg	10.5kg	1.75 lbs	5lbs	1.2 kg	540 g	0.6lbs
Radio Compatibility		Motorola, Harris,iCOM etc	Motorola, Harris,iCOM etc	YES	Motorola, Hytera, etc	Motorola, Hytera, etc	Motorola, Hytera, etc	Motorola, Hytera, etc	Motorola, Hytera, etc	YES	YES	YES	YES	YES
Operating System		LINUX		LINUX	Built-in VxWorks RTOS	Built-in VxWorks RTOS	Built-in VxWorks RTOS	Built-in VxWorks RTOS	Built-in VxWorks RTOS					LINUX
GPS	YES													

Table 1: Commercial Gateways with specifications

2.3 Components used

There are a number of electronic components used in the project. These components are as follows:

- LM358 IC
- Relay 5V DC
- PC817 Optocoupler
- Basic electronic components

2.3.1 LM 358 IC

LM358 is a dual operational amplifier integrated circuit (IC) that has two operational amplifiers (Op-Amp) supplied by a single power source. It is made up of two separate compensated operational amplifiers with high gain frequency and minimal power. The LM358 is specifically made to function from a single source over a broad voltage range.

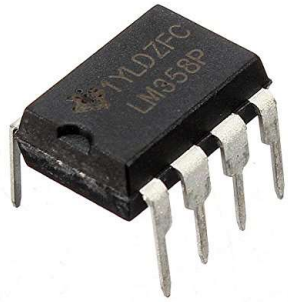

Figure 1: LM358 IC

PIN CONFIGURATION:

Pin configuration of LM358 is as follows:

- Pin1 and Pin7 are output pins of Op-Amp.
- Pin2 and Pin6 are inverting input pins of Op-Amp.
- Pin3 and Pin5 are non-inverting input pins of Op-Amp.
- Pin4 is the ground terminal (GND) pin of the IC.
- Pin8 is the power supply (Vcc) pin of the IC.

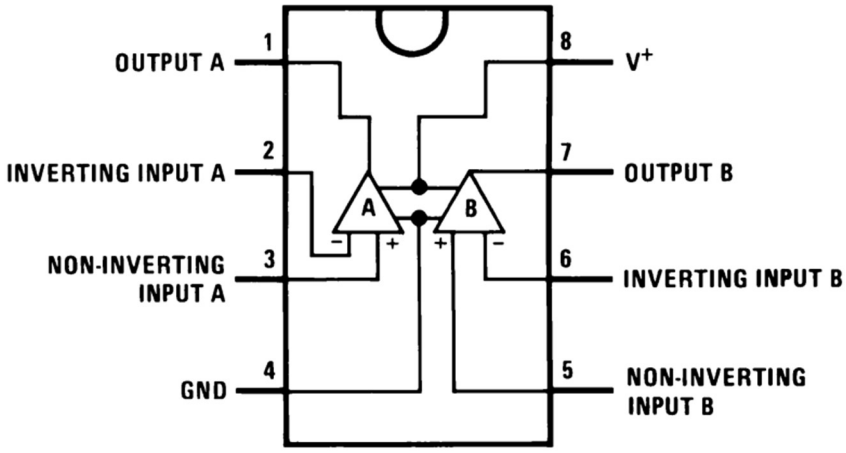

Figure 2: LM358 IC Pin Configuration

FEATURES AND SPECIFICATIONS:

- Two Op-Amp in a single package.
- Single power supply range is 3V-32V.
- Dual power supply from ±1.5V to ±16V.
- Around 100dB is the large voltage gain.
- Bandwidth is wide in 1MHz.
- Low supply current is of 700µA.
- Ambient temperature range of operation is 0˚C-70˚C.
- Temperature of soldering pin is 260˚C.
- Outputs are protected from short circuits.
- High output voltage swing.
- Similar differential input voltage to supply voltage.
- For unity gain, internal frequency compensation.
- Ground is included in the input common-mode voltage spectrum.
- TO-99, DSBGA, PDIP, SOIC, CDIP are the available packages.

WORKING:

Pin8 is the power supply input pin, So, we'll enter a source voltage ranging from 3 to 32 volts into the LM358 comparator if we want to operate it. On the other hand, we can supply it with a voltage between 1.5 and 16 volts if we wish to utilize the device as an operational amplifier (Op-Amp). The LM358 contains dual Op-Amps (as seen in the schematic diagram graphic above). Pins 2 and 3 serve as the first amplifier (A)'s inputs, and pin 1 serves as the device's output. In a similar manner, pins 5 and 6 serve as the inputs and pin 7 serves as the output of the second amplifier (B).

For a comparison of the two signals, we will connect one signal to pin 2 and the second one to pin 3. Pins 2 and 6 represent two different outputs, The output A and B, and the voltages of each will be checked with the 3rd and 5th pin.

If the input at pin number 3 is greater compared to the input at inverting input at pin number 2, the output of operational-amp A will turn out to be high. If the input at Non-inverting Input B (+) at pin number 5 is greater in value than the input at Inverting Input B at pin number 6, the resultant value of operational-amp B will become high.

On the contrary, if the input at Non-inverting Input A (+) on 3rd pin has a lower value compared to the value at Inverting Input at second pin, the output of operational-amp A is going to be low as well. Output of operational-amp B would show low if input at Non-inverting Input B (+) at 5^{th} pin is more compared to the input at Inverting Input B (-) on 6^{th} pin.

APPLICATIONS:

- Function generator
- Op-Amp circuit
- Comparators (Loop control and regulation)
- Voltage reference
- Filters

2.3.2 Relay (DC 5V)

Relays are switches that are controlled electrically. It consists of input pins for multiple controlling impulses as well as a set of functioning contact endpoints. The switch may have any number of contacts in various connection topologies, including make or break contact, even combinations of all.

Figure 3: Relay 5V

PIN CONFIGURATION:

The relay used in the project is 5V DC relay having pin configuration as follows:

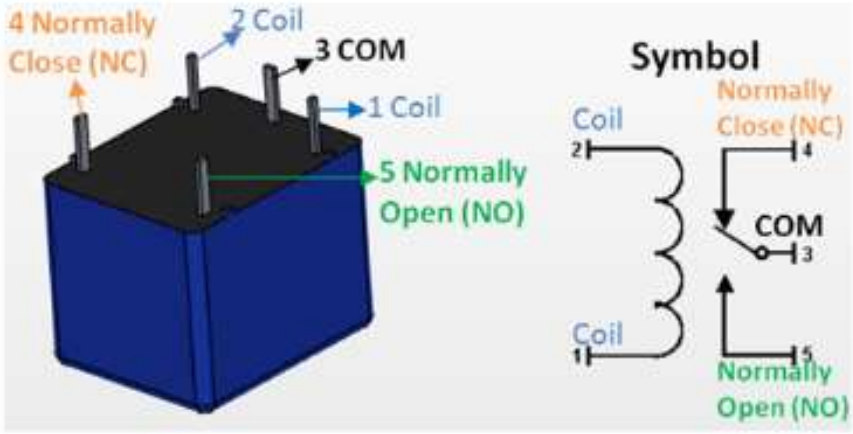

Figure 4: Pin Configuration of 5V relay

Pin Number	Pin Name	Description
1	end 1of coil	In order to turn the relay on or off. If the other coil pin is connected to 5V, then it will be connected to ground and vice versa
2	end 2 of coil	Used to turn/trigger (ON/OFF) the relay. If the other coil pin is connected to 5V, then it will be connected to ground and vice versa
3	Common (COM)	One end of our load (which we want to controll) is connected to COM pin
4	Normally Close (NC)	NC pin is connected to other end of the load, so the load remains connected before turning/triggering ON the relay
5	Normally Open (NO)	NO pin is connected to other end of the load, so the load remains disconnected before turning/triggering ON the relay

Table 2: Relay 5V Pins Description

FEATURES AND SPECIFICATIONS:

- Required voltage across the coil to turn on the relay is 5V DC.
- Required current across the coil to turn on the relay is 70mA.
- 10A @ 250/125V AC is the maximum AC load power.
- 10A @ 30/28V is the maximum DC load current.
- Plastic modeling and a compact 5-pin arrangement.
- 10msec is the operating time.
- 5msec is the release time.
- Mechanically 300 operations/min is the maximum switching.

WORKING:

Relays are among the most often used switching mechanisms in electronics. Before developing a system for operating the relay, two crucial relay factors must be taken into consideration. The trigger voltage is the amount of voltage required to activate the circuit and shift the connection from NC pin to NO pin. The relay in question requires 5 volts to turn on. The second parameter is the maximum voltage which NC, NO, and Common pin will tolerate in DC. These values for the relay in use are 30 Volts and 10 Ampere. Make sure to operate it in these ranges.

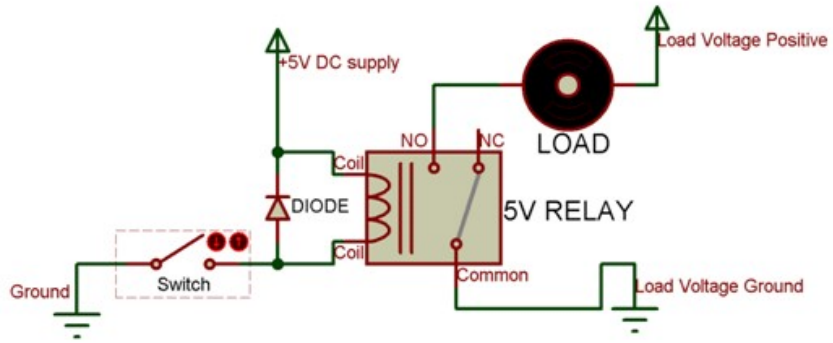

Figure 5: 5V Relay Working

The circuit above demonstrates the bare-minimum idea of how a relay works. A 5V DC source is supplied to one end of the coil and a switch to connect the other end of the coil to ground because the relay has a 5V trigger voltage. This switch may be any device that can perform switching operations, such as a tiny transistor, a microcontroller, or a microprocessor. A diode is also connected to the coil of relay. Protecting the switch from high voltage peaks that the relay circuit could produce is the diode's responsibility. The load can be wired so that one end is linked to the Common port while the remainder is either NO or NC, as shown in the diagram. If the load is linked to NO, it remains detached prior to trigger, and if it is attached to NC, it stays connected.

APPLICATIONS:

- Switching circuits
- Switching AC loads for home automation.
- Disconnects the load from supply in safety circuits in case of failure.
- Used in automobiles electronics to regulate things like indicators, glass motors, etc.

2.3.3 PC817 Optocoupler

Optocoupler is a type of semiconductor device, also known as an optoisolator, photo-coupler, or optical isolator, enables the transmission of electrical signals between two separated circuits via light. PC817 optocoupler contains an infrared (IR) diode and a phototransistor.

Figure 6: Optocoupler

PIN CONFIGURATION:

Pin configuration of PC817 optocoupler is as follows:

Figure 7: Optocoupler Pin Configuration

Pin Number	Pin Name	Description
1	Anode	It is the anode pin of infrared LED in the optocoupler IC. This pin provides a logical input signal to the internal IR.
2	Cathode	It is the anode pin of infrared LED in the optocoupler IC. Through the circuit and power supply, this pin will provide the infrared to generate the common ground potential.
3	Collector	This pin serves as the logical output (o/p) by receiving the infrared signal and is an o/p lead of the IR transmit (Tx) in the optocoupler.
4	Emitter	This pin serves as the IR receive (Rx) IC's GND and is used to create a common GND for the entire circuit and power source.

Table 3: Optocoupler Pin Description

FEATURES AND SPECIFICATIONS:

- The input diode's forward voltage is 1.25V.
- The highest current ratio at the collector terminal is 50mA.
- The Collector-Emitter's highest voltage is 80V. (max)
- The ratio of the highest voltage at the Collector & Emitter Terminals is 80V.
- Collector current can maximize up to 50mA.
- Rise Time is 18µs.
- Fall time is also18µs.
- 80 kHz is the cutoff frequency.
- A maximum working temperature of between -30 and 100 degrees is possible.
- 200mW is the power dissipation.
- 100 ohms is the internal impedance.
- This IC has an internal storage temperature range of -55 to 125 degrees.
- The optocoupler can withstand temperatures up to 260 degrees while being soldered. The IC will become harmed once the temperature rises.
- This IC has four pins and is offered in the SMT and DIP versions.
- This IC has internal protection from electrical isolation for both the input and output, and it protects up to 5KV.
- In order to operate through fewer voltage devices, this IC is used with an extra resistor through high voltage devices.
- Any type of device, including internal interfaces like microcontrollers and Transistor-Transistor Logic (TTL) devices, as well as HIGH DC voltage through some internal resistors, can make this IC work.
- Due to the one-way current flow, the PC817 Optocoupler has internal protection against reverse current; this IC protects the IR from any current.

WORKING:

The PC817 IC is very simple to use; only the anode pin of the IR LED (pin1) be connected to the pin2 be connected to ground. Now using a resistor (1kΩ used in the circuit below), pull the transistor's collector bit high and connect it to the output of the logic circuit which has to be used. Pin4 (the emitter) is grounded.

It should be noted that the ground lines of the transistor (pin4) and the IR LED (pin2) would not be linked. The isolation takes place here.

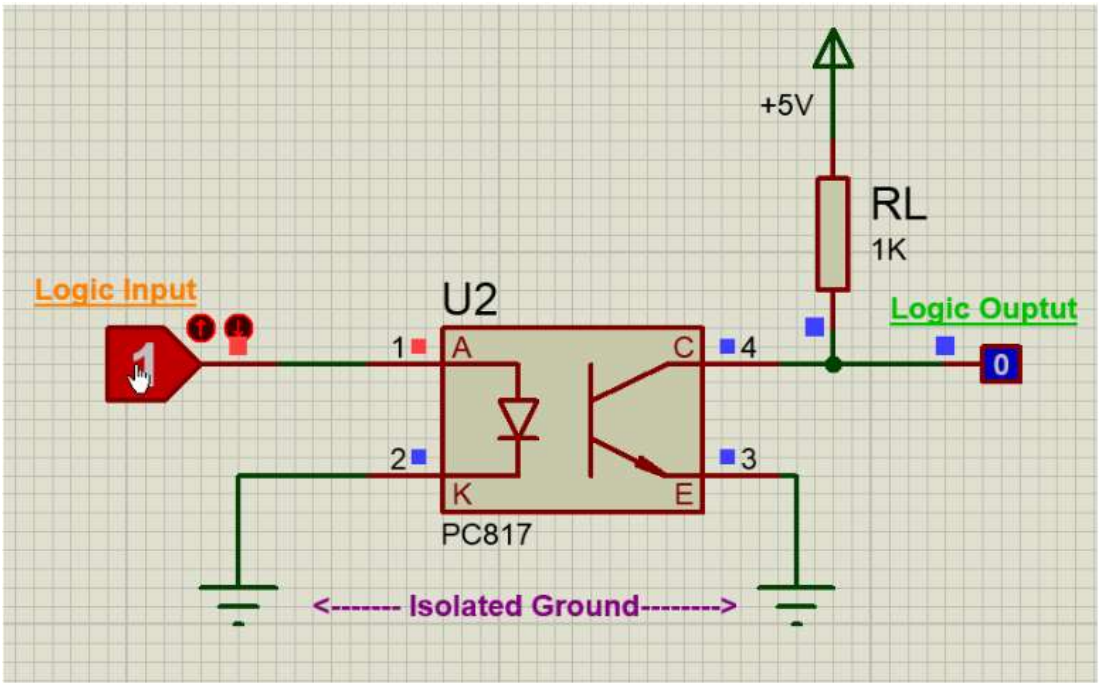

Figure 8: Optocoupler Working Diagram

Now, When the logic input is low, the IR LED won't light up; as a result, the transistor will likewise be in the off state. Since the collector-emitter voltage can be changed to any value between +5V and 30V in this situation, the logic output will remain high. A 1k ohm resistor serves as a load resistor in the circuit.

However, the LED conducts and the phototransistor turns on when the logic input is set high. This high voltage (Diode Forward voltage) should be at least 1.25V. This will result in a negative voltage for the logic output and a short between the collector and emitter. The logic input will be mirrored at the logic output in this way, but their separation will be preserved.

Another important thing to think about is the optocoupler's rise (tr) and fall time (tf). The output cannot become high once the input logic is made low and vice versa.

APPLICATIONS:

PC817 optocoupler is used in:

- Circuits for electrical isolation
- Circuits for toggling I/O on microcontrollers
- Circuits for signal separation and noise coupling
- Separation of analogue and digital circuitry
- AC/DC power management

2.3.4 Basic electronic components

The list of basic electronic components, which are used in the project, are as follows:

- 10kΩ, 39kΩ, 1MΩ, 1kΩ, 2.2kΩ resistors
- 200kΩ potentiometers
- BC547 transistors
- 10µF, 2.2 µF electrolytic capacitors
- 100pF, 100nF ceramic capacitors
- Light emitting diodes (LEDs)
- 1N4004 diodes

Figure 9: Basic Components

Chapter 3: Radios

The project is for the interoperability of radios. The main focus of the project was the integration of tactical radios. Following radios are used for this project:

- HARRIS RF5800H MP
- HARRIS RF7800S
- Aselsan SDR 9661
- Aselsan LMR SK2

3.1 HARRIS:

American manufacturer Harris Technologies, Inc. creates wireless equipment, tactical radios, avionics and electronic systems, night vision gear, and both terrestrial and spaceborne antennas for use in the public sector, defense, and commercial sectors. Harris Technologies, Inc. also provides information technology services.

3.1.1 HARRIS RF5800H MP

Harris RF-5800 developed by Harris Corporation is tactical radio system for use by military and government agencies. It consists of a variety of handheld, manpack, and vehicular radios that provide secure voice and data communications in a diverse range of frequency bands. The RF-5800H-MP is a well-known manpack radio that operates in the HF frequency range, allowing for long-distance communications. It supports voice, data, and video transmissions and has an integrated GPS receiver for location tracking. Also providing features for external use by an external connector. These connectors have pins of varying features such as speaker, microphone, Push To Talk (PTT), keyline and ground.

Figure 10: HARRIS RF5800H MP

3.1.2 HARRIS RF7800S

The Secure Personal Radio (SPR), RF – 7800S is a tactical handheld radio intended for use in the field by both law enforcement and military personnel. SPR offers secure voice and data communications in a modest and rugged bundle. It supports numerous of waveforms, including the Single Channel Ground and Airborne Radio System (SINCGARS), Have Quick II, and Integrated Waveform (IW), and operates in the frequency range of 30–512 MHz.

Another function is provided for external connections. Connector is provided externally for the connections. Each pin on the connector performs a certain task. There are multiple speaker pins, microphone pins, Push To Talk (PTT), 5V power supply and a ground pin.

Figure 11: HARRIS RF7800S

3.2 Aselsan:

Turkish defense company Aselsan A.S, has its headquarters in Ankara. Its primary business activity is the research, development, and production of cutting-edge military equipment for use by land, air, and sea forces. ASELSAN creates, develops, and produces advanced technology electronic systems for commercial and military applications in Turkey and globally.

3.2.1 Aselsan SDR 9661

Figure 12: Aselsan SDR 9661

Aselsan Software Defined Radio (SDR) is a versatile and adaptable radio system that can operate in wideband, narrowband, and multi-band modes. It has a maximum output power of 20 watts and can operate at frequencies ranging from 1 MHz to 3 GHz. It also supports different waveforms, such as frequency hopping and digital modulation schemes. SDR is a radio communication system in which most of the signal processing is done in software rather than hardware. Also having external connectors for extension usage of PTT, speaker, microphone, keyline and ground.

3.2.2 Aselsan LMR SK2

Figure 13: Aselsan LMR SK2

Aselsan LMR (Land Mobile Radio) is a radio communication system used by military, security, and law enforcement agencies for tactical communication. LMR is a digital radio system that can operate in a variety of frequency bands and modes. It can be set up to operate in a point-to-point or point-to-multipoint communication network, allowing for reliable and secure voice and data communication in harsh environments.

Chapter 4: Voice Activated Switch (VOX)

A voice-activated switch (VOX) is the main component of our device. It is an electronic circuit that allows the device to be turned on or off by detecting the person's voice. It detects sound waves and converts them into electrical signals, which activate the switching mechanism. It is often utilized in devices such as hands-free communication systems, in which a user's voice can activate or deactivate the microphone or speaker, or in radio PTT automation.

4.1 Amplification

The project use audio input for voice activated switch from the radio speaker but the signal is weak. The signal is first passed through an amplifier to amplify the signal. The amplification is done using LM358 IC.

4.2 Power Supply

The VOX circuit utilizes basic electrical components and an IC for amplification, so therefore power supply is required. The circuit can be powered at 5V minimum and 10V maximum.

4.3 Voice Operated Switch

VOX is frequently used in radios to automatically switch a transmitter between receive and transmit modes when the user speaks into the microphone. This allows for hands-free operation and can enhance communication efficiency.

4.4 Sensitivity Control

The VOX circuit detect audio signal, processes it and then activate the switch. The timing for activating the switch can be adjusted by controlling the sensitivity of VOX. Thus, improving the efficiency of the circuit

.

Chapter 5: Voice Gateway

The working of this project is divided into multiple phases depending on the characteristics of radios. Each radio has different features and provide different functions and are characterized into phases according to these features.

The gateway takes voice input from a radio speaker and transfers it into voice activated switch and enables the radio at the other end to transmit the signal by activating the PTT of the radio. And as output the audio signal from radio operating at different net is transmitted and received by the radio operating at different net.

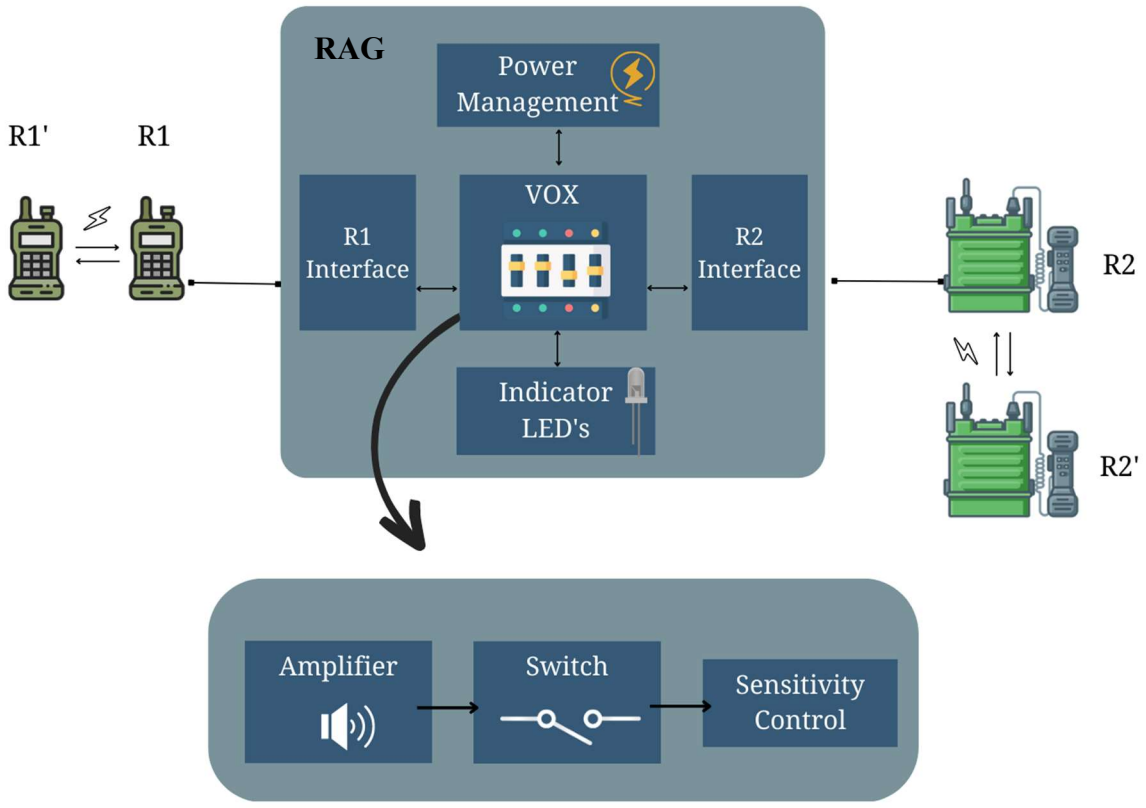

Figure 14: Working of Gateway

5.1 Phase – I:

Depending on the features the interoperability of different radios can differ. This phase focuses on the radios having the keyline feature. The keyline feature helps minimize the static noise when the radio is transmitting, thus providing ground on the external connector.

The keyline of radio at net-1 is used to activate the PTT of the radio operating at radio net-2 or radios of different OEMs. During the transmission the keyline pin in the connector is providing ground. Thus, providing connection from keyline to PTT, it enables the radio at the other end to transmit the signal in its network.

In this phase the radios of the following OEMs are made interoperable using the afore-cited mechanism.

- Interoperability of HARRIS – SDR

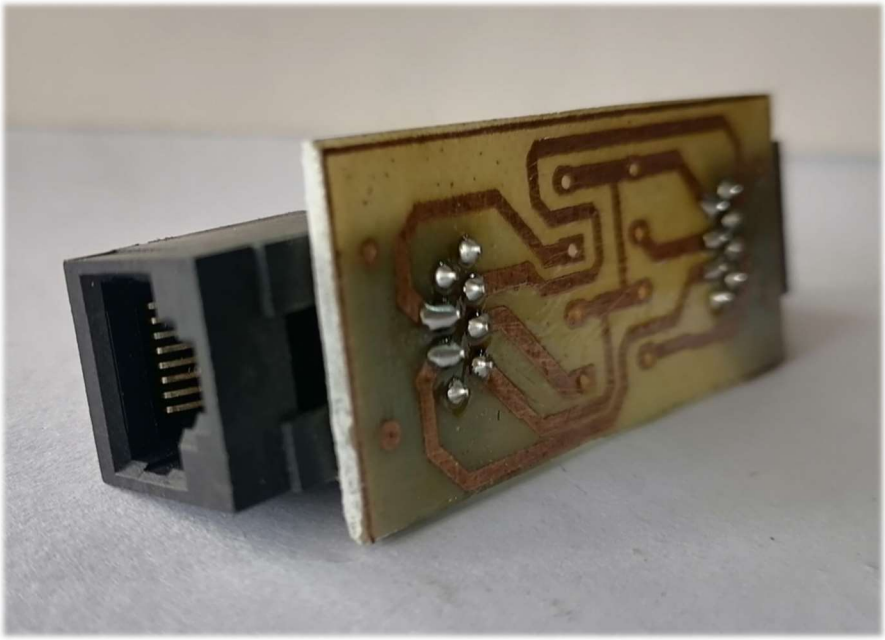

Figure 15: PCB design of Phase – 1 Device

5.2 Phase – II:

In this phase, one radio has the keyline feature and the radio at the other end does not have external keyline feature. The mechanism is slightly different from the phase – 1.

During the transmission of signal from the radio with keyline, the PTT is provided ground from the keyline pin and signal is received at the other end like phase – 1. When the signal is transmitted from the other end the signal is passed to the voice activated switch. It is processed by VOX and signal is amplified. The switch detects the signals and activates the radio PTT and thus the signal is transmitted to the radio operating at a different network.

Using the mechanism, the interoperability of radios of following OEMs was made possible:

- Interoperability of HARRIS – LMR
- Interoperability of SDR - LMR
- Interoperability of HARRIS - SPR
- Interoperability of SDR – SPR

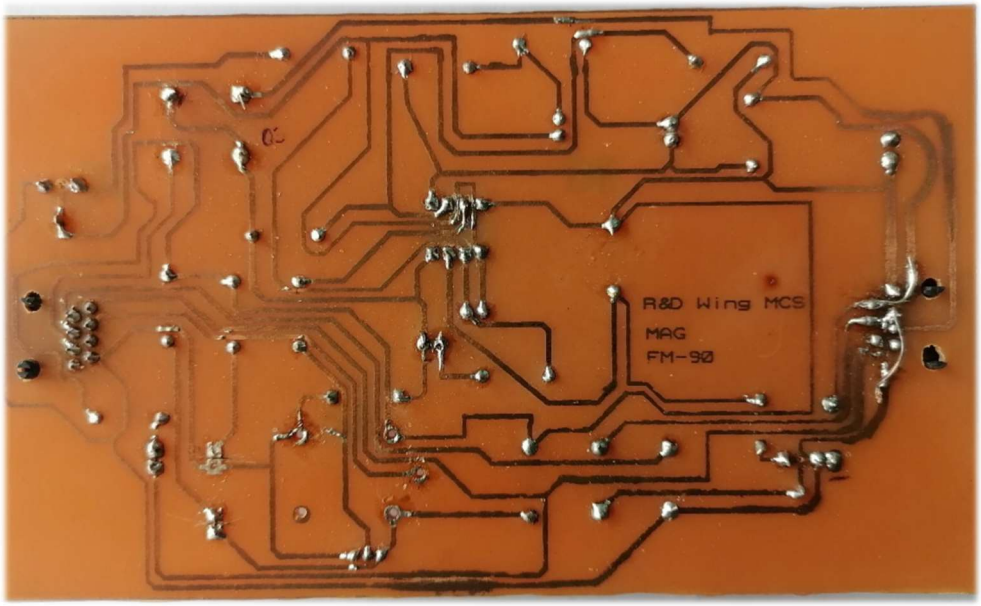

Figure 16: PCB design of Phase – 2 Device

Chapter 6: Product Specification

Product: Radio Audio Gateway (RAG)

Functionality: Audio Gateway

Components: RAG unit, Interface cables

6.1 Technical Data:

Operating Voltage: 5 Volts

Color: Black

Frequency range: It can operate on any frequency being used by radio network.

Power Supply: Gateway is powered via battery of the radio.

6.2 Phase-I

6.2.1 Pin configuration:

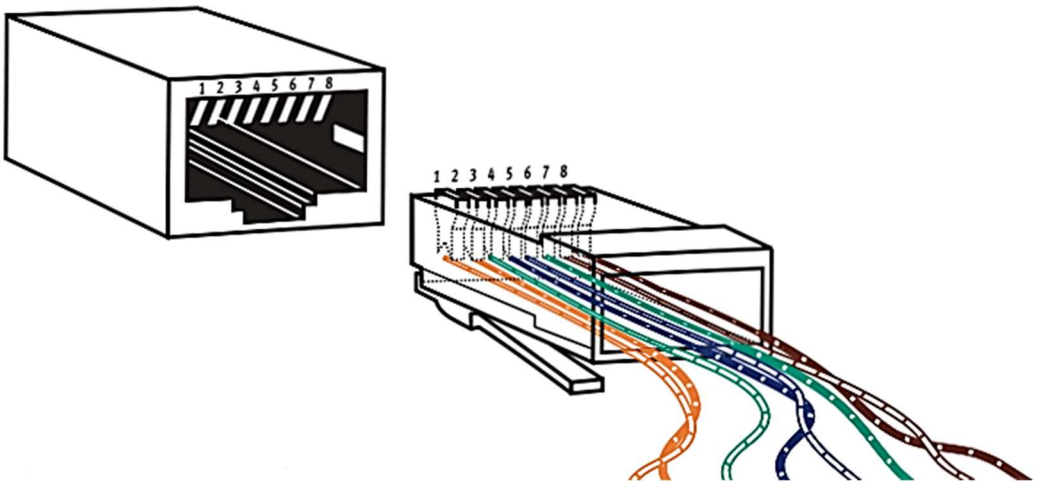

Figure 17: RJ45 Male and Female Connector

Pin Number	Description
1	RFU
2	Ground
3	PTT
4	Speaker
5	Microphone
6	Keyline
7	RFU
8	RFU

Table 4 : Phase – I device pin configuration

6.2.2 Dimensions:

Length: 70mm

Height: 30mm

Width: 34mm

Figure 18 : Phase – I device

6.2.3 Interface Cables:

Figure 19: Phase – I HARRIS interface cable

Figure 20: Phase – I SDR interface cable

6.3 Phase-II

6.3.1 Pin configuration:

Pin Number	Description
1	VCC
2	Ground
3	Speaker +
4	Speaker -
5	Microphone
6	PTT
7	Keyline
8	RFU

Table 5 : Phase – II device pin configuration

6.3.2 Dimensions:

Length 110 mm

Height: 42mm

Width: 70mm

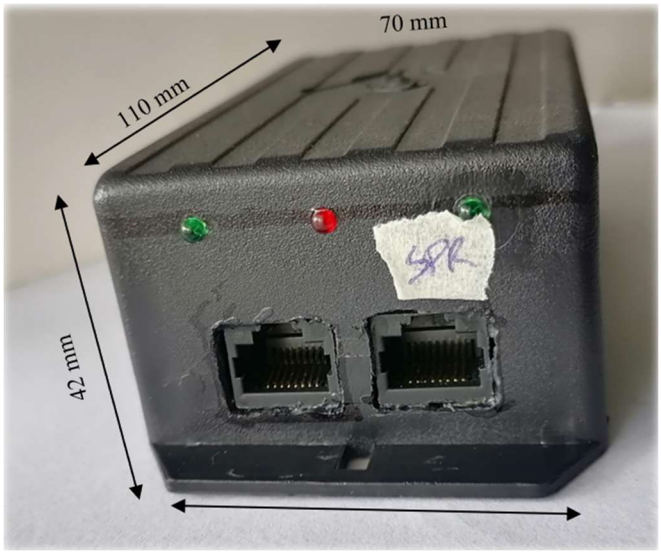

Figure 21: Phase – II device

6.3.3 Interface Cables:

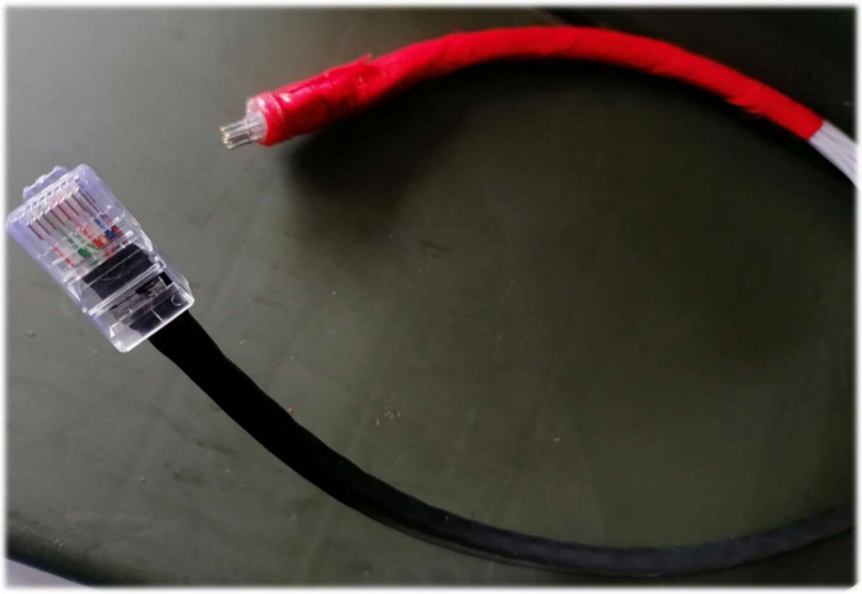

Figure 22: Phase – II SPR interface cable

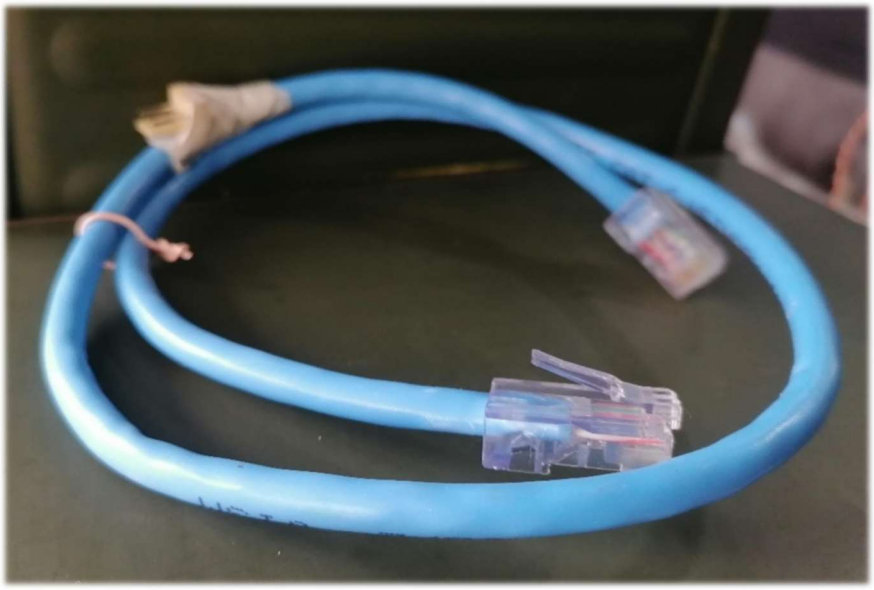

Figure 23: Phase – II LMR interface cable

Chapter 7: Conclusion

This document elaborates the work done on the radio audio gateway. It acts as a bridge between radios of different OEMs and makes them compatible to communicate with each other. The existing audio gateway has many modern features which are used for multiple purposes, but they also come with drawbacks which are catered in this project. Some features are not used frequently but due to these features the cost of the gateways increases at an alarming rate. One of the features includes connection to the internet, that is a huge security vulnerability which makes it unsecure mean of communication for military purposes. The problems and drawbacks are handled using basic electrical components which are easily accessible and can be handled easily in case of any damage or any repairment required.

The proposed solution is cost effective and purely devolved for serving and provide benefit to the community using radio communication. Radio audio gateways are critical tools for improving communication in environments where multiple communication systems are required. Thus, providing a solution for enabling communication between various radio devices. Furthermore, the use of radio audio gateways can aid in the improvement of communication and collaboration among individuals, teams, and organizations, resulting in increased productivity, safety, and efficiency.

Chapter 8: Future Work

The following are future milestones which can be added in the project in order to be more applicable.

8.1 Phase - III

The above mechanism discussed in phase I and II is for either one radio or both of them having keyline feature provided externally at one of the connector pins. In addition, the radios without keyline feature can also be made compatible with radios of different OEMs. This will enhance communication for collaboration between multiple teams using radio sets of different manufacturers. The following radios fall under this category:

- Interoperability of SPR – LMR

References and Work Cited

1. Lin, J.-R., Pang, A.-C. and Wang, Y.-C. (2008), iPTT: peer-to-peer push-to-talk for VoIP. Wirel. Commun. Mob. Comput., 8: 1331-1343. [online] Available at: < https://doi.org/10.1002/wcm.588>.
2. Ivany Sarief, Denny Irawan, Nina Lestari, Kusmadi, Hartuti Mistialustina, Rudy Gunawan, "Implementation of Radio Over Internet Protocol Gateway for Police Station in Mountainous and Uncovered Areas", 2021 15th International Conference on Telecommunication Systems, Services, and Applications (TSSA), pp.1-4, 2021. [online] Available at: < https://ieeexplore.ieee.org/ />.
3. S. Tabsombat et al., "Push-to-talk control scheme for radio over IP communication," 2010 7th International Conference on Service Systems and Service Management, Tokyo, Japan, 2010, pp. 1-4, doi: 10.1109/ICSSSM.2010.5530189. [online] Available at: < https://ieeexplore.ieee.org />.
4. Chakraborty, T., Misra, I. S., Prasad, R., Chakraborty, T., Misra, I. S., & Prasad, R. (2019). Overview of VoIP technology. *VoIP Technology: Applications and Challenges*, 1-24.. [online] Available at: < https://scholar.google.com/scholar?as_q=Overview+of+VoIP+Technology&as_occt=title&hl=en&as_sdt=0%2C31 >.
5. Hsu Jenq-Muh, Lain Wei-Bin and Liang Jui-Chih, "A Context-Aware Push-to-Talk Service", *Proceedings of the 2008 International Conference on Multimedia and Ubiquitous Engineering*, 2008.
6. Alex Gilces-Zambrano, Dannyll Michellc Zambrano, Lorena Bowen-Mendoza, "Analysis of a Network Implementing ROIP Technology", *Emerging Research in Intelligent Systems*, vol.405, pp.178, 2022.

7. Richard Poisel, Modern Communicatoins Jamming Principles and Techniques. Norwood, USA: Artech House Inc, 2004.
8. Military Wireless Communications (MWC) Research Group, *"Military Wireless Communication (MWC) Group TNT / CBE 10-1 After Action Report,"* Naval Postgraduate School, Monterey, After Action Report 2009.
9. Dixon, Joshua & Xie, Geoffrey & Kragh, Frank. (2010). Integrating Cellular Handset Capabilities with Military Wireless Communications.
10. Voice Activated switch kit. Online available at <https://www.nonstopsystems.com/radio/pdf-hell/article-vox1.pdf >.
11. Kiley, Paul & Benedett, Thomas. (2007). Public Safety Interoperability with an SCA Military Radio using the P25 Waveform. 1 - 8. 10.1109/MILCOM.2007.4455208.
12. The SyTech Radio and Digital Intercom Unified System interoperability systems. Online available at https://www.sytechcorp.com/radius.
13. Gateway with communication interfaces like VoIP Gateway, GoIP gateway. Online available at http://www.niceuc.com/en/.
14. T. Ahmed and N. M. Khan, "A Simple and Low Cost Land-Mobile-Radio Design for Interoperability Among Radio Networks in a Public Safety Scenario," 2019 International Conference on Communication Technologies (ComTech), Rawalpindi, Pakistan, 2019, pp. 1-6, doi: 10.1109/COMTECH.2019.8737839.
15. Audio Gateway Handbook March 2006. Online available at < https://taccomms.org/wp-content/uploads/2019/Interop/Audio-Gateway-Handbook_320_Final.pdf>.
16. "Cognitive Gateway Design To Promote Universal Interoperability". Online available at https://www.wirelessinnovation.org/assets/Proceedings/2008/sdr08-1.6-3-chen.pdf.
17. "Voice activated circuit and radio using same." Online available at : < https://patents.google.com/patent/US6633847B1/en>.
18. Aselsan A.S Communications. [Online] at https://www.aselsan.com/tr.

19. Harris Corporation. (2009) Harris RF Communications. [Online] at www.rfcomm.harris.com.

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