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4G Signal Amplifier using 1800 MHz Yagi-Uda Antenna

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Abstract: The demand for high-speed mobile data access in rural, remote, and urban areas with weak cellular signals has led to the development of effective signal amplification systems. This project presents a 4G signal amplifier designed to enhance cellular signal reception using a Yagi-Uda antenna tuned to the 1800 MHz frequency band, which is widely used for 4G LTE services. The Yagi-Uda antenna is chosen for its high directional gain, compact design, and ability to focus reception in a specific direction, thereby minimizing interference from unwanted signals. The signal received by the antenna is amplified using a low-noise amplifier (LNA) to boost signal strength while maintaining signal integrity. The amplified signal is then relayed to a 4G modem or mobile device, improving data speeds, call quality, and network stability. The system is evaluated based on key parameters such as gain, signal-to-noise ratio (SNR), and coverage improvement. Results demonstrate that the Yagi-Uda antenna significantly enhances the reception of weak 4G signals, making it an effective solution for users in areas with poor network coverage. This project has potential applications in homes, offices, and vehicles, where reliable 4G connectivity is critical.
Keywords: 4G LTE, signal amplifier, Yagi-Uda antenna, 1800 MHz, low-noise amplifier, mobile connectivity.

I. INTRODUCTION

The increasing reliance on mobile communication and data services has made strong and consistent cellular signals a necessity. However, various factors, such as geographic location, building materials, and distance from the nearest cellular towers, often lead to weak 4G signals, resulting in dropped calls, slow internet speeds, and poor connectivity. To address this issue, signal amplification systems have become essential tools to enhance signal quality and extend coverage in areas with poor reception. This project focuses on designing and implementing a 4G signal amplifier specifically tuned to the 1800 MHz frequency band, which is widely used for 4G LTE services worldwide. At the heart of this system is the Yagi-Uda antenna, a high-gain directional antenna renowned for its ability to focus and capture weak signals over long distances. The system also incorporates a low-noise RF amplifier (LNA) to boost the received signal with minimal distortion and noise, followed by an omni-directional antenna to broadcast the amplified signal uniformly in all directions for improved coverage.

The key objectives of this project are:

- To design and fabricate a high-performance 1800MHz Yagi-Uda antenna.
- To integrate an efficient RF amplifier with low noise characteristics to ensure signal clarity.
- To enhance the quality and range of 4G signals in areas with poor network availability.

This project offers significant real-world applications, including improving connectivity in remote and rural areas, enhancing in door coverage in urban environments, and boosting signal strength in weak reception zones. By combining the directivity of the Yagi-Uda antenna, the amplification capability of the RF amplifier, and the wide coverage of the omni-directional antenna, this system provides an effective solution to common 4G signal issues.

Modern 4G signal boosters incorporate advanced technologies, such as:

- Smart Signal Detection: Automatically adjusts amplification levels to avoid interference with cellular networks.
- Multi-Band Support: Boosts multiple frequency bands simultaneously, enabling compatibility with different carriers and devices.
- Directional Antennas: Focus on specific towers for better performance in remote areas.

- Ease of Installation: Plug-and-play designs and app-based interfaces make setup simple for user.

1.2 MOTIVATION

In today's digital age, seamless mobile communication and high-speed internet connectivity are in dispensable for both personal and professional activities. The global adoption of 4GLTE technology has revolutionized telecommunications, enabling faster data transfer, improved voice quality, and a broader range of applications, from video streaming to IoT-based solutions. Despite its widespread adoption, achieving consistent and reliable 4G signal strength remains a challenge in many scenarios, especially in areas where signal degradation is common.

Weak 4G signals can occur due to several factors, including:

- Distance from Cellular Towers: Remote areas often lack sufficient infrastructure to provide strong 4G coverage.
- Physical Obstacles: Dense urban environments with tall buildings, concrete walls, and underground spaces obstruct signals.
- Interference: High levels of electromagnetic interference from other devices or networks reduce signal quality.
- Terrain Variations: Hilly or forested regions often experience signal attenuation due to natural barriers.

These challenges lead to frustrating user experiences, such as dropped calls, slow data speeds, and unreliable internet access. Addressing this problem is crucial for ensuring connectivity in underserved areas and improving the overall efficiency of communication networks. The Yagi-Uda antenna, with its high directional gain and ability to focus on weak signals, presents an excellent solution for capturing distant 4G signals. Coupled with an RF amplifier with low noise characteristics, it can significantly enhance signal strength and clarity. By broadcasting the amplified signal using a nomni-directional antenna, this system ensures wider coverage, making it suitable for rural areas, large buildings, and challenging terrains.

The motivation for this project stems from the pressing need to:

- Enhance 4G network availability in low-signal regions, bridging the digital divide in rural and remote areas.
- Improve signal quality in urban environments where dense infrastructure often leads to poor indoor reception.
- Provide a cost-effective and practical solution to boost 4G signals without requiring extensive infrastructure upgrades.

By designing a 4G signal amplifier tuned to the 1800MHz frequency band, this project aims to contribute to the advancement of telecommunications, ensuring reliable connectivity for users in diverse environments. This not only addresses a technical challenge but also supports societal goals by fostering digital inclusion and accessibility.

2. LITERATURE SURVEY

2.1 Novel approaches on 4G signal amplifier using 1800MHz Yagi-Uda antenna

1. Kevin Ming Jiang Ho's et al.,[1] research in 2020 focused on the development of impedance matching networks. The primary goal of this work was to maximize power transfer, minimize signal reflection, improve efficiency, and optimize bandwidth. The methodology employed involved the use of tunable matching network techniques. However, the study revealed several limitations, including the narrow operational bandwidth, the complexity of design, and the system's sensitivity to temperature variations, which could hinder its practical applications.
2. In 2018, Elizabeth N.Onwuka et al.,[2] carried out a study on cellular signal boosters aimed at improving network accessibility and performance in regions with poor connectivity. The study utilized booster fit techniques to enhance signal reception and provide better coverage. Despite its contributions to improving connectivity, the study identified challenges such as interference issues, regulatory constraints, limited operational range, and high power dependency, which limit the widespread adoption of this technology.
3. Divela Santhosh's etal.,[3] work in 2021 investigated the efficiency improvement of bidirectional amplifiers. The study's objective was to enhance signal quality and improve the efficiency of cellular system procedures. The research implemented a tri-band cellular repeater technique to achieve its goals. Nevertheless, the study faced significant challenges, including installation complexity and power losses, which could complicate the deployment of such systems in real-world applications.
4. In 2019, Salihu Oladimeji et al.,[4] focused on GSM boosters aimed at improving speed and efficiency. The study targeted enhancing GSM signal strength, extending coverage, improving call quality, and simplifying installation and maintenance. Bandwidth filters were used as part of the methodology to optimize the system. However, the research highlighted several limitations, including restricted range, potential interference with networks, regulatory compliance issues, and dependency on the quality of existing signals.
5. Saksham Jain's et al.,[5] research in 2020 focused on the simulation and design of a network signal booster operating at 1800MHz. The study aimed to enhance network coverage and improve signal strength while ensuring reliability and user-friendly installation. A 1800MHz Yagi-Uda antenna was used as a key component to achieve these objectives. The findings demonstrated improved network performance; however, the study primarily concentrated on the1800MHz band and did not extend to other frequency ranges.
6. Omkar S. Dalvi's et al.,[6] study in 2019 emphasized improving mobile signal reception strength using a network booster. The objectives included enhancing mobile signal strength, expanding coverage, reducing call drops, and ensuring ease of installation. The methodology involved optimizing the Low Noise Amplifier (LNA) within the booster system. Despite its benefits, the study highlighted limitations such as reduced effectiveness under extreme conditions, potential interference, regulatory challenges, and reliance on existing signal quality.
7. WenRao Fang's et al.,[7] work in 2020 introduced a simple and universal measurement method for evaluating the efficiency of pulse RF power amplifiers. The study utilized a self-designed power amplifier to measure efficiency accurately and with minimal complexity.

8. However, several limitations were noted, including challenges in measurement accuracy, calibration complexity, and sensitivity to noise, bandwidth constraints, and environmental interferences that could affect practical Implementation
9. In 2021, Shrief Rizkalla et al. [8] focused on the design and optimization of a low-cost booster for HFRF ID cards. The objective was to enhance range and efficiency using RFID card-based techniques. While the study achieved cost-effective solutions, it faced limitations such as signal interference, restricted range, power constraints, material compatibility challenges, and trade-offs in performance.
10. Roar Daniel et al.,[9] conducted a study in 2021 on the design and optimization of low-cost boosters for various applications. The research focused on improving power amplifier efficiency with universal applicability and minimal complexity. A self-designed power amplifier was employed for testing. However, the study faced challenges similar to other RF amplification systems, including calibration complexity, sensitivity to noise, bandwidth constraints, and measurement accuracy issues.
11. Zhiun Zhou's et al.,[10] study revolved around the front-end RF amplifier with current compensation feedback. The research aimed to enhance linearity, reduce distortion, and improve stability in RF amplifier systems. A self-designed RF amplifier was used to achieve these goals. Despite its advancements, the study encountered limitations such as design complexity, potential oscillations, noise sensitivity and reduced gain.

2.2 Objectives of Proposed Methodology

- **Improve Signal Strength**

  The primary objective of the 4G signal amplifier using an 1800 MHz Yagi-Uda antenna is to improve the reception of weak 4G LTE signals, particularly in areas with poor network coverage. By utilizing the Yagi-Uda antenna's high directional gain, the system aims to capture and focus the signal from distant base stations, thereby increasing the strength and clarity of the signal. This improved reception results in better connectivity, reduced dropped calls, and more stable data connections, enhancing the overall user experience in environments where signal quality is typically suboptimal.

- **Maximize Antenna Gain and Directivity**

  Maximizing antenna gain and directivity involves designing the antenna to focus electromagnetic energy in a specific direction, improving signal strength and reception efficiency. Antenna gain amplifies the signal by concentrating energy in a preferred direction, enhancing reception from distant sources and reducing interference. Directivity refers to the antenna's ability to focus on signals from a specific direction, creating a narrow beam of reception. Together, high gain and directivity improve the signal-to-noise ratio (SNR), increase coverage range, and reduce interference, especially in challenging environments like remote areas or urban "dead zones," ensuring optimal 4G signal performance.

3. DESIGN AND IMPLEMENTATION

3.1 Implementation

The implementation of a 4G signal amplifier involves several key components and steps, ensuring that the amplified signal improves coverage and performance without interference or signal degradation. Below is a detailed outline of the implementation process.

3.1.1 Components and Equipment

The following components are necessary for constructing the system:

- 1800 MHz Yagi-Uda Antenna: Acts as the directional antenna for receiving weak 4G signals.
- Low Noise Amplifier (LNA): Amplifies the weak signal received from the Yagi-Uda antenna while minimizing noise.
- RF Power Amplifier: Boosts the signal to a stronger level for transmission to the desired area.
- Omni-Directional Antenna: Redistributes the amplified signal to a wider area for user devices.
- Coaxial Cables: Connects the antennas and amplifiers while minimizing signal loss.
- Power Supply: Provides consistent voltage and current for the amplifier and antenna systems.
- Filters: Ensures unwanted frequencies or noises are suppressed for better signal clarity.

3.1.2 System Design

The design of the 4G signal amplifier involves the following stages:

- **Signal Reception**

The Yagi-Uda antenna is positioned and aligned to capture the 1800 MHz frequency band of 4G signals. Its high directivity ensures efficient reception of weak signals from a distant base station.

- **Signal Amplification**

The weak signal from the Yagi-Uda antenna is fed into the Low Noise Amplifier (LNA). The LNA amplifies the signal without adding significant noise, ensuring that the signal-to-noise ratio (SNR) remains high. The amplified signal is then passed to an RF Power Amplifier. This amplifier further boosts the signal strength, making it suitable for distribution.

3.1.3 Signal Transmission

After amplification, the signal is transmitted to an Omni-Directional Antenna, which redistributes it over a wide coverage area. This ensures that multiple user devices can receive the boosted 4G signal effectively.

3.1.4 Filtering and Noise Suppression

Band-pass filters are employed to isolate the 1800MHz frequency band and remove unwanted noise or interference from nearby frequencies.

3.1.5 Hardware Assembly

- Mount the Yagi-Uda antenna outdoors, ensuring it is aligned with the nearest 4G tower for maximum signal reception.
- Connect the Yagi-Uda antenna to the LNA using high-quality coaxial cables to minimize signal loss.

- Attach the output of the LNA to the RF power amplifier.
- Connect the output of the RF power amplifier to the omni-directional antenna, ensuring proper impedance matching to reduce reflections and losses.
- Power the entire system using a regulated power supply, ensuring adequate voltage levels for all components.

3.1.6 Software and Tuning

- Frequency Tuning: Configure the system to operate specifically with in the 1800MHz band to avoid interference with other bands.
- Gain Adjustment: Adjust the amplifier's gain to ensure sufficient signal strength without causing distortion or interference.
- Direction Optimization: Adjust the Yagi-Uda antenna orientation for maximum signal reception.

3.1.7 Testing and Validation

- Signal Strength Measurement: Use a spectrum analyzer or a signal strength meter to measure the signal before and after amplification.
- Coverage Area Testing: Evaluate the range of the boosted signal to ensure it meets the intended coverage requirements.
- Quality of Service (QoS): Monitor the signal quality, including parameters like SNR, throughput, and latency.

3.1.8 Challenges and Mitigation

- Interference: Ensure proper shielding of cables and components to reduce external noise interference.
- Over-amplification: Avoid signal distortion by carefully setting the amplifier gain.
- Alignment Issues: Use a signal strength meter during Yagi-Uda antenna alignment to achieve the best results.

3.2 COMPONENTS REQUIREMENTS

3.2.1 YAGI UDA ANTENNA

Definition:

A Yagi-Uda antenna is a directional antenna system consisting of multiple parallel elements, typically one driven element (dipole), one reflector, and several directors. It is widely used in telecommunications for its high gain and directional properties.

Purpose: In a 4G signal amplifier, the Yagi-Uda antenna boosts and directs signals effectively to enhance connectivity in areas with weak 4G LTE signals.

Key Features:

- Frequency Range: 1800 MHz
- Gain: 12-15 dBi
- Number of directors: 8
- Number of driven elements: 1
- Number of reflectors:1
- Beamwidth: 45° to 60°
- Impedance: 50 Ohm
- Connector Type: N-Female
- Length: 60 cm

Role in 4G Signal Amplifier: For 1800 MHz frequency bands, the Yagi-Uda antenna amplifies incoming and outgoing 4G LTE signals, improving data transfer rates and reducing signal loss in remote areas**.**

Design and Specifications of the 1800 MHz Yagi-Uda Antenna:

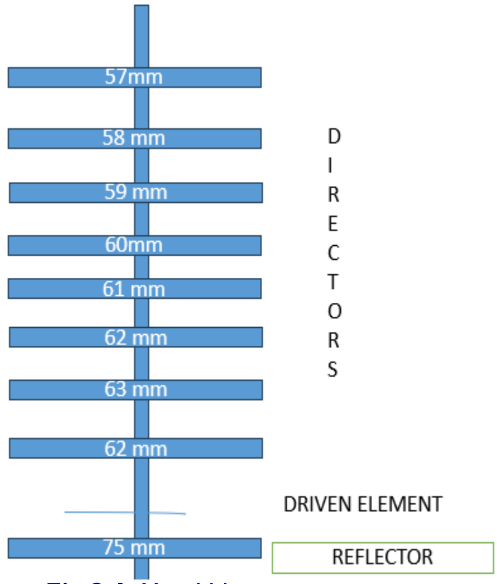


Fig 3.1: Yagi-Uda antenna

This design demonstrates a Yagi-Uda antenna for 1800 MHz with multiple elements for optimal gain and directionality. Here's a detailed breakdown:

1. Antenna Components:

- Reflector (1 Element) : Length: 75 mm (slightly longer than the resonant wavelength for effective reflection).
- Driven Element (1 Element): Length: Resonates at 1800 MHz (typically calculated as half the wavelength, around 71.4 mm).
- Positioned centrally, serves as the main signal receiver/transmitter.
- Directors (9 Elements): Gradual reduction in length (57–63 mm), aligned in the direction of signal propagation for gain enhancement.

2. Design Dimensions:

- Spacing: Typical spacing between elements: 0.2λ to 0.4λ (approx. 28–57 mm at 2100 MHz).
- Reflector to Driven Element: Approximately 0.25λ (35.7 mm).
- Director spacing: Gradual, optimized for maximum directivity and impedance matching.

3. Key Parameters:

- Operating Frequency: 1800 MHz.
- Wavelength (λ): ~142.86 mm.
- Gain: Typically ranges from 8–14 dBi, depending on the number of directors.
- Impedance: Designed to match a standard 50-ohm system.

3.2.2 RF Amplifier with Low Noise Amplifier (LNA)

Definition: An RF Amplifier with a Low Noise Amplifier (LNA) is an electronic circuit used to amplify weak radio frequency (RF) signals while minimizing noise. The LNA is typically the first amplification stage in a system, designed to boost signals without introducing significant additional noise.

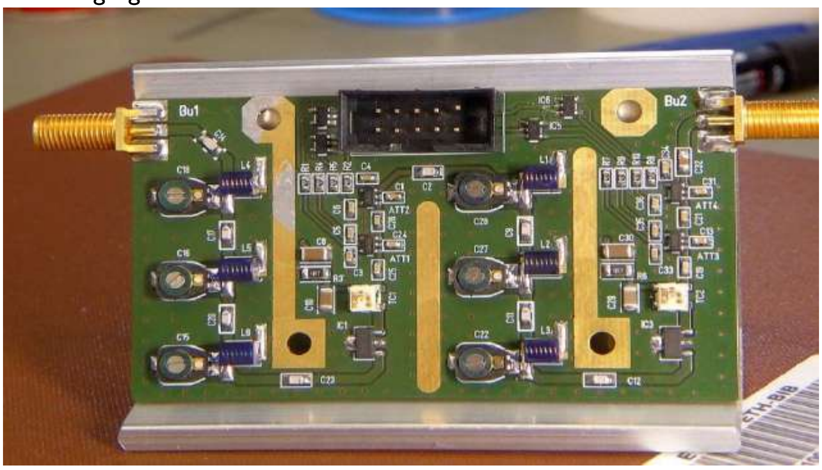


Figure: 3.2: RF Amplifier

Purpose: In a 4G signal amplifier, the RF amplifier with LNA ensures that weak signals from the 1800 MHz Yagi-Uda antenna are amplified effectively for better reception and transmission.

Key Features:

- Frequency Range: 1MHz-2GHz
- Gain: 20 dB
- Input / Output Impedance: 50 Ohms
- Output Voltage :12 V
- Connector Type: SMA-Female

Role in the Project:

- Improves Signal Quality: Amplifies incoming 1800 MHz signals from the Yagi-Uda antenna with minimal noise.
- Enhances Range: Enables the system to detect and utilize weak signals in remote or low-signal areas.
- Prevents Signal Loss: Prepares the amplified signal for further stages, like transmission or conversion to digital formats.
- This component is critical in ensuring robust 4G signal performance and effective communication in challenging environments.

3.2.3 12V DC Adapter

Definition: A 12V DC adapter is a device that converts standard AC mains electricity (110V or 220V) into a steady 12V DC output, used to power various electronic components.

Purpose: In a 4G signal amplifier, the 12V DC adapter provides the required power supply for the amplifier circuitry, ensuring stable operation.

Key Features: Input Voltage: 100-240V AC

- Current: 2 A
- Output voltage : 12 V DC

Role in the Project: It powers the signal amplifier's active components, enabling proper amplification of the 1800 MHz signal for better 4G connectivity.

3.2.4 RG58 Coaxial Cable

Definition: RG58 is a type of coaxial cable commonly used for transmitting radio frequency (RF) signals. It consists of a central conductor, dielectric insulator, metallic shield, and outer insulation.

Purpose: In a 4G signal amplifier setup, RG58 connects the Yagi-Uda antenna to the amplifier or receiver, transmitting signals with minimal loss.

Figure:

Fig 3.3: RG58 Coaxial Cable

Key Features:

- Type: RG58/U Coaxial Cable
- Impedance: 50 Ohm
- Frequency Range: 1800-2200 MHz
- Connector Type: SMA(female)

Role:

The RG58 cable ensures efficient signal transmission from the 1800 MHz Yagi-Uda antenna to the amplifier, minimizing signal attenuation and ensuring reliable 4G signal performance.

3.2.5 Omni directional Antenna (12 dBi Gain)

Definition: An Omni directional Antenna is an antenna that radiates power uniformly in all horizontal directions, providing 360° coverage. A 12 dBi gain indicates high efficiency in signal reception and transmission.

Purpose: In a 4G signal amplifier system, it helps distribute the amplified signal uniformly over a wide area, improving connectivity in all directions.

Fig 3.4: Omni directional Antenna

Key Features:

- Frequency Range: 1800-2200 MHz
- Gain: 12 dBi
- Polarization: Vertical
- Beam width (Horizontal): 360°
- Beam width (Vertical): 75°
- Impedance: 50 Ohms
- Connector Type: SMA female

Role: In combination with a 1800 MHz Yagi-Uda antenna, the omni directional antenna ensures broad signal coverage while the Yagi-Uda antenna provides directional signal enhancement, improving overall system performance.

Here's an explanation of each block:

1. Power Supply (5V and 1A)

- Provides the necessary power to the RF amplifier, which is a crucial component for boosting the signal.
- Ensures stable operation of the amplification circuit.

2. Yagi Uda Antenna

- **Frequency:** 1800 MHz (specific to 4G signals in this frequency range).
- **Gain**: 8-12 dBi (a measure of the antenna's ability to focus the signal in a particular direction, providing high directionality).
- **Function:** Captures weak incoming 4G signals from a specific direction, thanks to its directional nature. This makes it ideal for rural or low – signal areas where signals come from far-off towers.
- After capturing the signal, it sends it to the RF amplifier for boosting.

3.2 FLOWCHART

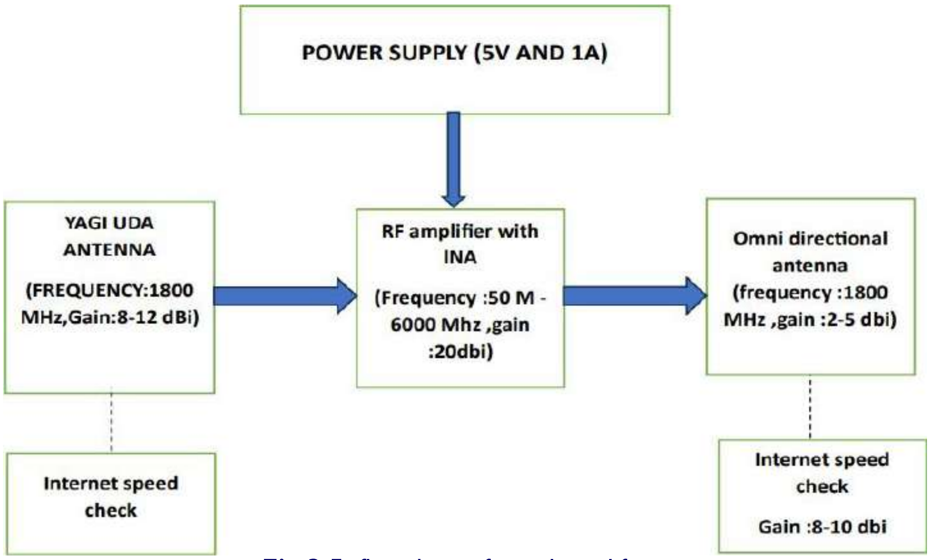


Fig 3.5: flowchart of signal amplifier

This block diagram illustrates a 4G signal amplifier system designed to enhance the strength of signals operating at the 1800 MHz frequency band.

3. **RF Amplifier with INA (Integrated Noise Amplifier)**

- **Frequency Range**: 50 MHz to 6000 MHz, making it capable of amplifying signals across abroad range of frequencies.
- **Gain**: 20dBi (amplifies the incoming signal significantly, improving its strength before transmitting it further).
- Function: Boosts the weak signal received from the Yagi Uda antenna while minimizing noise interference. This ensures a cleaner, stronger output signal.

4. **Omni directional Antenna**

- **Frequency**: 1800MHz.
- **Gain**: 2-5dBi (moderate gain, designed to broadcast the amplified signal in all directions).
- Function: Redistributes the amplified signal uniformly in all directions. This is particularly useful for providing enhanced 4G coverage over a wide area, such as within a building or house.

5. **Internet Speed Check**

- Represents the testing points for verifying the system's performance.
- Before and after amplification, internet speed checks can confirm the improvement in signal quality and strength, correlating with better internet speeds.

System Workflow

1. The YagiUda antenna captures weak 4G signals in a specific direction.
2. The signal is sent to the RF amplifier, where it is amplified.
3. The amplified signal is fed into the omni directional antenna, which broadcasts the stronger signal to surrounding devices.
4. Internet speed tests at the input (Yagi Uda) and output (Omni directional) validate the system's efficiency. This setup is ideal for boosting 4G signals in areas with poor network coverage. The directional Yagi Uda antenna ensures effective signal capture, while the omni directional antenna ensures wide spread signal redistribution.

3.3 Working principle

The working principle of a 4G signal amplifier system using a1800 MHz Yagi Uda antenna is based on the reception, amplification, and redistribution of weak signals. Below is a detailed explanation:

1. **Signal Reception (YagiUda Antenna)**

- **Function**: The YagiUda antenna is a directional antenna designed to focus on a specific direction to receive signals effectively. It has: Ahigh gain (8-12dBi) for enhancing signal reception.
- Narrow beam width to ensure it captures weak 4G signals at 1800 MHz from far-away cell towers.
- **Process**: The antenna captures weak signals from a specific direction, filters noise, and sends the signal to the amplifier via a coaxial cable.

2. **Signal Amplification (RF Amplifier with INA)**

- **Function**: The RF amplifier boosts the strength of the weak signal received from the Yagi Uda antenna while reducing noise interference. It has:
  - Abroad frequency range (50MHz – 6000 MHz), suitable for 4G signals (1800MHz in this case).
  - High gain (20dBi) for significant signal amplification.
- **Process**:
  - The weak signal is fed into the amplifier.
  - The amplifier strengthens the signal, ensuring better quality and a wider coverage area.
  - An integrated low-noise amplifier (INA) minimizes the addition of unwanted noise during amplification.

3. **Signal Redistribution (Omni directional Antenna)**
- **Function**: The omni directional antenna takes the amplified signal and broad casts it uniformly in all directions. It has:
  - A moderate gain (2-5d Bi) to ensure balanced signal coverage over a wide area.
- **Process**:
  - The amplified signal is fed to the omni directional antenna.
  - The antenna radiates the stronger signal, enabling 4G devices with in its range to access better connectivity and higher internet speeds.

4. **System Feedback and Verification**
- **Internet Speed Check**: The effectiveness of the system can be tested by comparing internet speeds at the input (signal captured by the Yagi Uda antenna) and output (signal redistributed by the omni directional antenna).
- This validates the improvement in signal quality and strength.

Key Working Principle
1. Directional signal capture: The Yagi Uda antenna captures weak 4G signals at 1800MHzfrom a specific direction.
2. Signal enhancement: The RF amplifier boosts the signal strength while minimizing noise.
   Omni directional redistribution: The omni directional antenna rebroad casts the amplified signal for use by nearby devices.

1. **Capturing the Signal:**
- The Yagi antenna is installed outdoors in allocation where the mobile signal is relatively stronger, such as on the roof or an elevated area. The Yagi antenna is a directional antenna with high gain, typically ranging from 8-12dBi, which focuses on receiving signals from a specific direction. It is aligned toward the nearest cell tower to capture the incoming weak mobile signal in frequency bandslike900 MHz, 1800 MHz, or 2100 MHz(GSM, 3G, 4GLTE)

3.4 Methodology

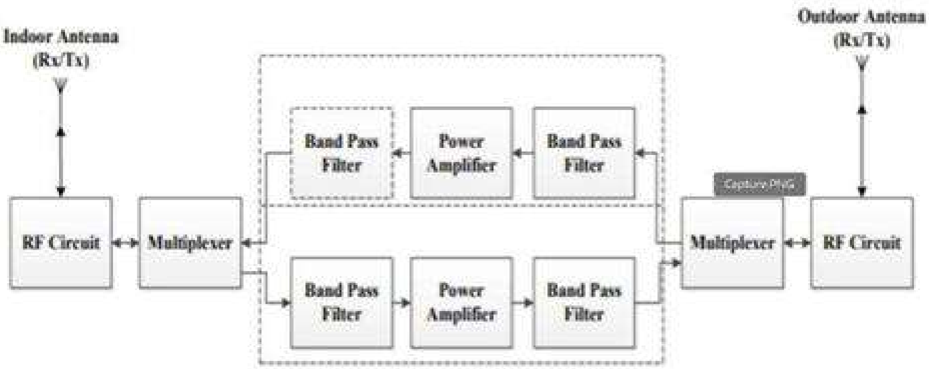


Fig 3.6: Block diagram

2. **Signal Transmission to RF Amplifier:**
- The weak signal captured by the Yagi antenna is sent through a coaxial cable (e.g.,RG-58orRG-174) to the RF amplifier
- The coaxial cable maintains the integrity of the signal by minimizing losses during transmission.

3. **Signal Amplification:**
- The RF amplifier (LNA) receives the weak signal and amplifies it. The amplifier used in this project operates over a wide frequency range (0.1-2000 MHz) and provides again of30 dB.
- Amplifying the signal is crucial, as it enhances the signal strength sufficiently for indoor redistribution, ensuring a stronger, more stable mobile signal.
- The amplifier is powered by a regulated DC power supply (either 5V or 12V), and proper power filtering capacitors are used to avoid noise or signal distortion.

4. **Rebroad casting the Amplified Signal:**
- The amplified signal is then transmitted from the output of the RF amplifier to an omni directional antenna through another coaxial cable.
- The omni antenna, mounted indoors, redistributes the amplified signal in all directions, providing improved signal strength to mobile devices with in its coverage area (typically a room or a small building).
- This setup ensures that mobile devices like smart phones and tablets receive a much stronger signal than before, enabling clearer voice calls, faster data speeds, and stable connectivity.

5. **System Optimization:**
- Ensure sufficient distance and isolation between the Yagi antenna (outdoors) and the omni directional antenna (indoors) to avoid feedback and oscillations. Ideally, this distance should be at least 10-15 meters.
- Fine-tuning the Yagi antenna's direction is crucial for maximizing signal reception. This can be done by slowly rotating the antenna and checking

4. RESULT AND DISCUSSION

4.1 Result and discussion

The result of using a 4G signal amplifier with an 1800 MHz Yagi-Uda antenna depends on the specific setup, including environmental factors, antenna design, and the amplifier's quality. Here's what you can generally expect:

Key Performance Metrics:

1. **Signal Strength Improvement**:

- A well-designed 1800 MHz Yagi-Uda antenna can provide a gain of 8–12 dBi or higher.
- Combined with an amplifier, you might see a signal strength improvement of 20–40 dB (depending on the amplifier's gain).

2. **Coverage Range**:

- The amplifier, when paired with a directional Yagi antenna, can extend the 4G coverage by several kilometers in rural or open areas.
- In urban settings, the range improvement might be less due to interference and obstacles.

3. **Download/Upload Speeds**:

- Improved signal strength can result in higher data rates. For instance, weak signals (< -110 dBm) might only support 1–2 Mbps, but a boosted signal (> -85 dBm) could achieve 10–50 Mbps, depending on the network capacity.

4. **Signal-to-Noise Ratio (SNR)**:

- A Yagi-Uda antenna improves SNR by focusing on the signal from a specific direction, reducing interference from other sources

4.2 Experimental observation and setup

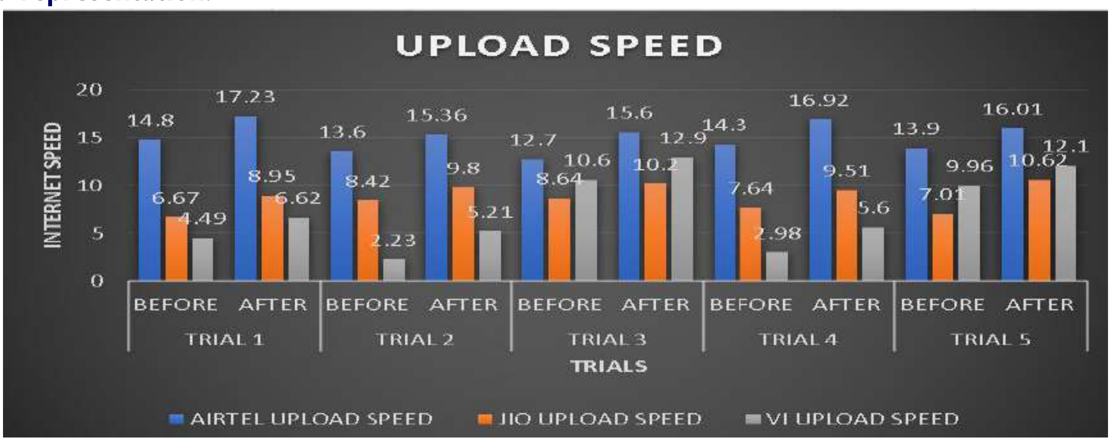
4.2.1 Location: IS ROHAL Old Airport Road

Table 4.1 Signal strength measurement near ISRO

No. of Trials		AIRTEL		JIO		VI	
		Download Speed	Upload Speed	Download Speed	Upload Speed	Download Speed	Upload Speed
Trial 1	Before	22.2	14.8	20.7	6.67	6.64	4.49
	After	25.9	17.23	22.8	8.95	7.95	6.62
Trial 2	Before	13	13.6	12.8	8.42	7.09	2.23
	After	15.89	15.36	14.2	9.8	9.29	5.21
Trial 3	Before	11.4	12.7	26.8	8.64	6.75	10.6
	After	14.2	15.6	29.2	10.2	8.89	12.9
Trial 4	Before	13.6	14.3	22.2	7.64	6.69	2.98
	After	16.23	16.92	24.6	9.51	8.56	5.6
Trial 5	Before	13.2	13.9	24.5	7.01	9.89	9.96
	After	17.01	16.01	27.2	10.62	11.2	12.1

Fig 4.1: Experimental setup near ISRO

Graphical representation:



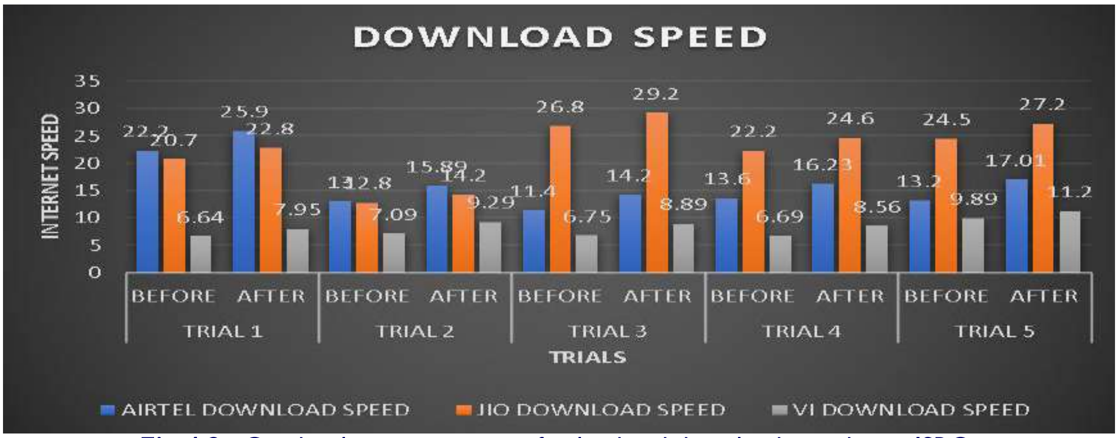


Fig 4.2 : Graphical representation of upload and download speed near ISRO

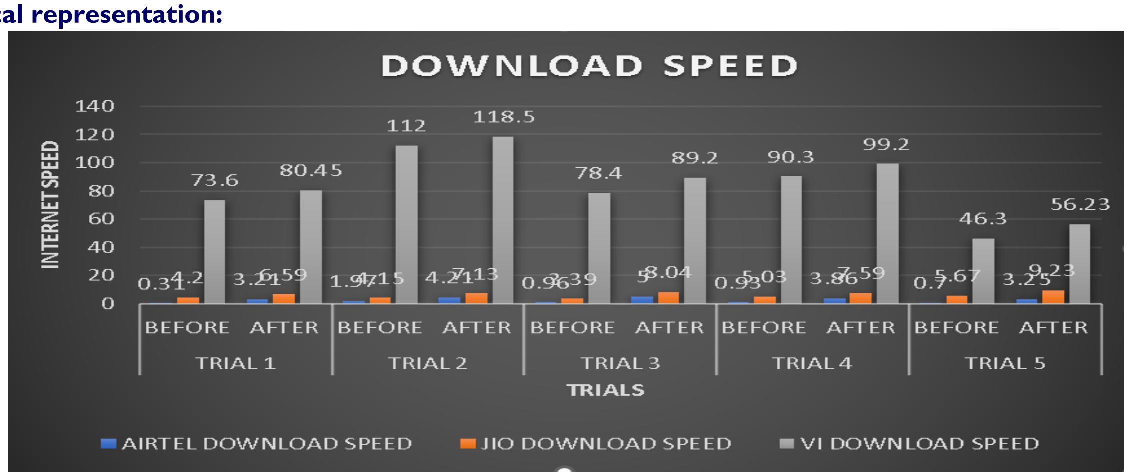
Fig 4.3: Experimental setup near NAL lab

4.2.2 LOCATION: NALLABKODI HALLI

Table 4.2 Signal strength measurement near NAL lab

NO. of Trials		AIRTEL		JIO		VI	
		Download Speed	Upload Speed	Download Speed	Upload Speed	Download Speed	Upload Speed
Trial 1	Before	0.31	3.44	4.2	2.62	73.6	12.2
	After	3.21	5.96	6.59	6.74	80.45	16.2
Trial 2	Before	1.97	2.95	4.15	1.87	112	14.6
	After	4.21	5.23	7.13	4.2	118.5	20.35
Trial 3	Before	0.96	3.46	3.39	2.34	78.4	12.8
	After	5	7.12	8.04	6.3	89.2	19.5
Trial 4	Before	0.93	2.25	5.03	2.11	90.3	6.15
	After	3.86	6.01	7.59	6.08	99.2	12.5
Trial 5	Before	0.7	2.2	5.67	2.34	46.3	8.87
	After	3.25	5.89	9.23	5.89	56.23	15.6

Graphical representation:



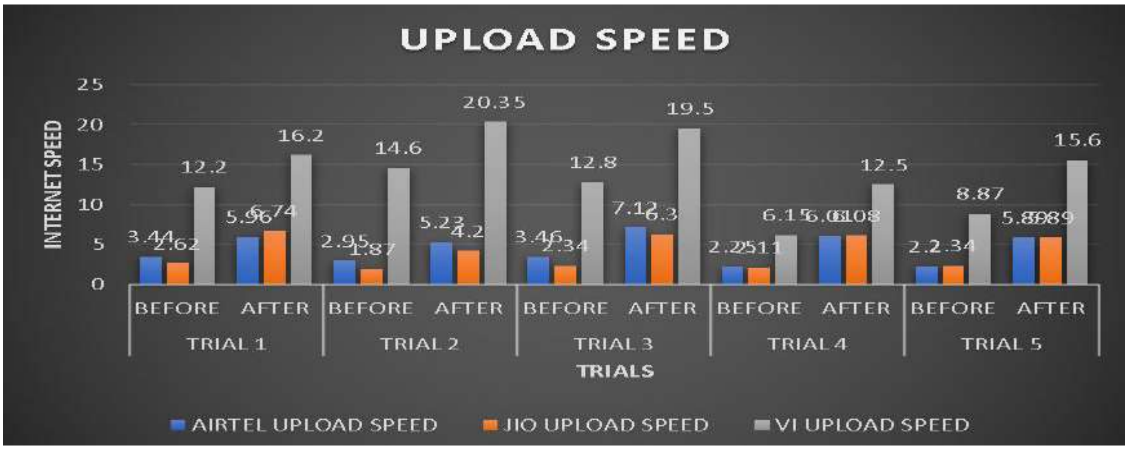


Fig 4.4: Graphical representation of upload and download speed near NAL lab

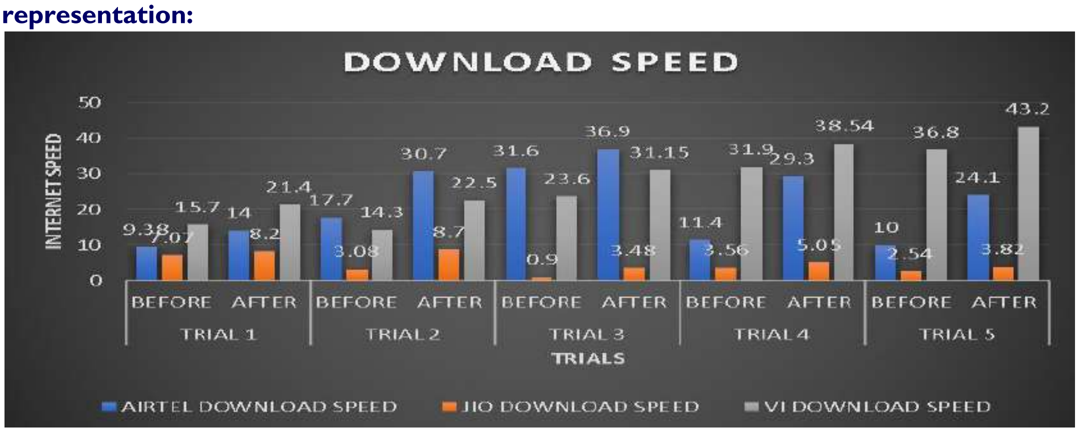
LOCATION: BIT COLLEGE K.R MARKET ROAD

Table 4.3 Signal strength measurement in BIT College

NO. of Trials		AIRTEL		JIO		VI	
		Download Speed	Upload Speed	Download Speed	Upload Speed	Download Speed	Upload Speed
Trial 1	Before	9.38	9.89	7.07	1.14	15.7	0.99
	After	14	14.36	8.2	6.74	21.4	2.56
Trial 2	Before	17.7	8.41	3.08	7.14	14.3	1.51
	After	30.7	14.2	8.7	12.1	22.5	389
Trial 3	Before	31.6	8.29	0.9	0.04	23.6	1.75
	After	36.9	15.6	3.48	2.08	31.15	4.15
Trial 4	Before	11.4	3.27	3.56	3.22	31.9	2.64
	After	29.3	14.1	5.05	6.08	38.54	5.14
Trial 5	Before	10	6.19	2.54	0.09	36.8	1.55
	After	24.1	17.2	3.82	2.1	43.2	3.98

Fig 4.5: Experimental setup in BIT College

Graphical representation:



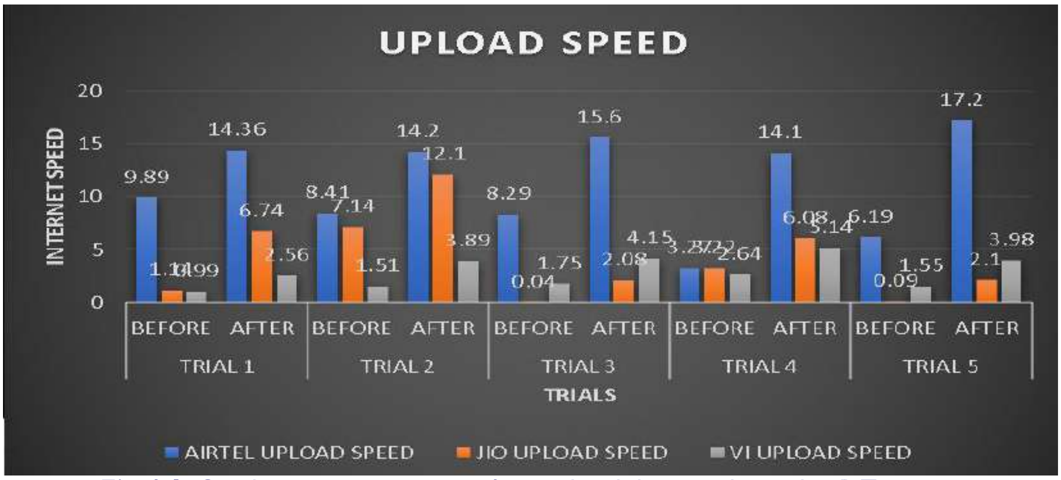


Fig 4.6: Graphical representation of upload and download speed in BIT college

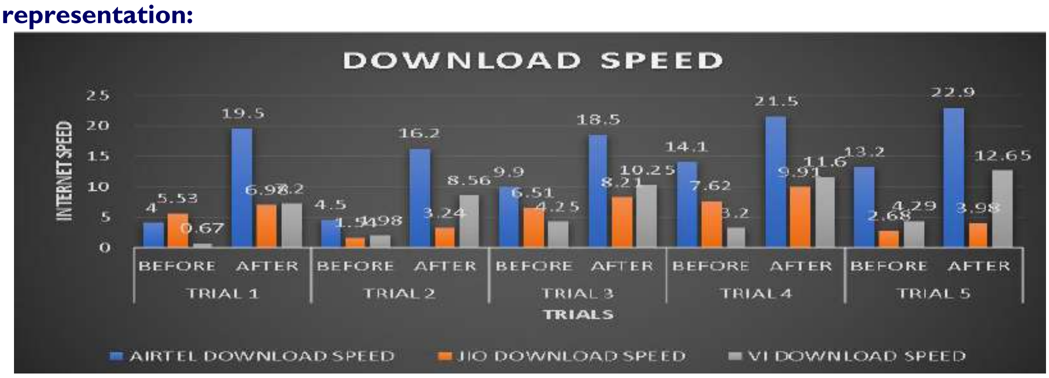
4.2.3 LOCATION: NEAR LAKE AECS LAYOUT

Table 4.4 Signal strength measurement near Lake

NO. of Trials		AIRTEL		JIO		VI	
		Download Speed	Upload Speed	Download Speed	Upload Speed	Download Speed	Upload Speed
Trial 1	Before	4	3.3	5.53	0.07	0.67	0.83
	After	19.5	7.09	6.98	1.23	7.2	6.62
Trial 2	Before	4.5	5	1.54	0.12	1.98	0.99
	After	16.2	9.2	3.24	1.32	8.56	7.56
Trial 3	Before	9.9	7.34	6.51	0.19	4.25	0.41
	After	18.5	11.2	8.21	1.23	10.25	8.71
Trial 4	Before	14.1	0.78	7.62	0.26	3.2	0.09
	After	21.5	3.45	9.91	3.21	11.6	5.6
Trial 5	Before	13.2	4.13	2.68	0.1	4.29	1.81
	After	22.9	7.56	3.98	0.99	12.65	8.01

Fig 4.7: Experimental setup near Lake

Graphical representation:



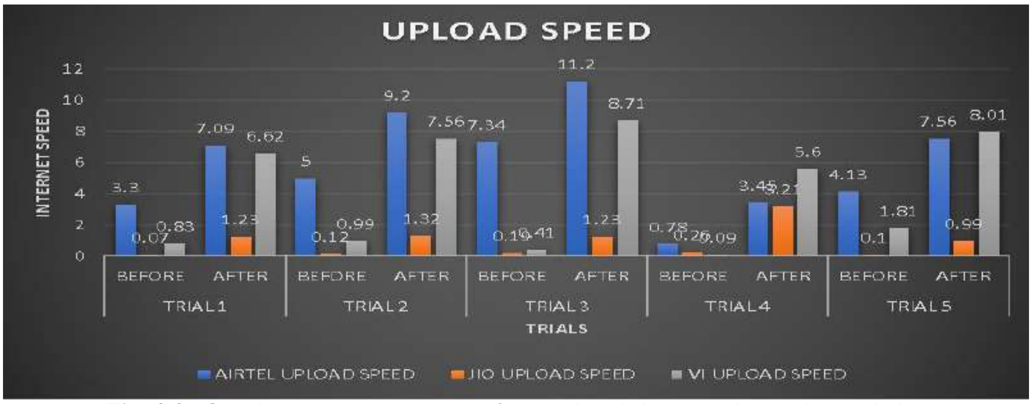


Fig 4.8: Graphical representation of upload and download speed near Lake

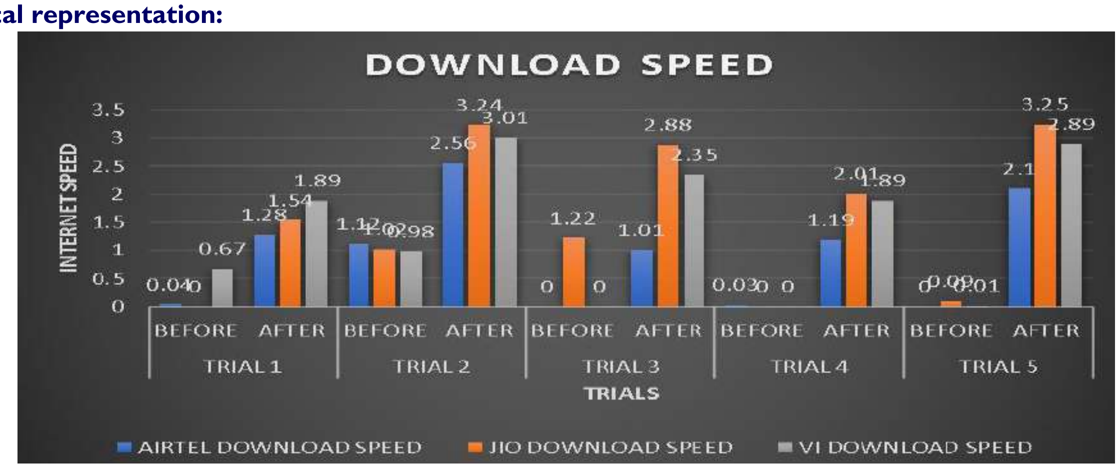
4.2.4 LOCATION: CONSTRUCTION SITE ROHANEKANTA, GUNTUR

Table 4.5 Signal strength measurement near Construction area

NO. of Trials		AIRTEL		JIO		VI	
		Download Speed	Upload Speed	Download Speed	Upload Speed	Download Speed	Upload Speed
Trial 1	Before	0.04	0	0	0	0.67	0.83
	After	1.28	1.03	1.54	1.23	1.89	3.65
Trial 2	Before	1.12	0	1.02	0.12	0.98	0.99
	After	2.56	2.01	3.24	1.32	3.01	3.68
Trial 3	Before	0	0	1.22	0.19	0	0.41
	After	1.01	1.91	2.88	1.23	2.35	3
Trial 4	Before	0.03	0.01	0	0.26	0	0.09
	After	1.19	1.74	2.01	3.21	1.89	2.87
Trial 5	Before	0	0	0.09	0.1	0.01	0.56
	After	2.1	0.91	3.25	2.84	2.89	3.99

Fig 4.9: Experimental setup near construction area

Graphical representation:



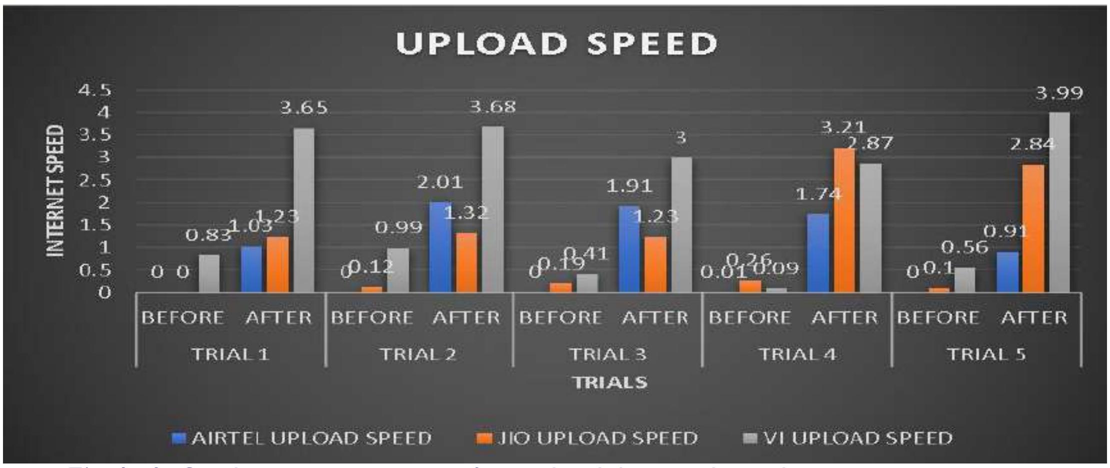


Fig 4.10: Graphical representation of upload and download speed near construction area

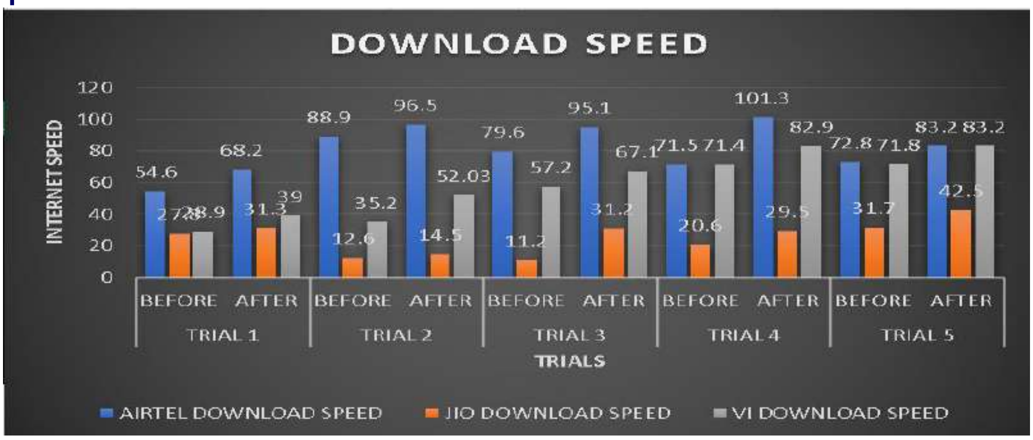
4.2.5 LOCATION: NAGARJUNA PGS.G PALYA

Table 4.6 Signal strength measurement near densely populated area

NO. of Trials		AIRTEL		JIO		VI	
		Download Speed	Upload Speed	Download Speed	Upload Speed	Download Speed	Upload Speed
Trial 1	Before	54.6	9.32	27.8	24.6	28.9	26.1
	After	68.2	11.8	31.3	27	39	32.65
Trial 2	Before	88.9	8.43	12.6	14.8	35.2	24.8
	After	96.5	12.3	14.5	22.1	52.03	30.1
Trial 3	Before	79.6	10.1	11.2	24.3	57.2	23.1
	After	95.1	14	31.2	31.5	67.1	29.98
Trial 4	Before	71.5	6.12	20.6	3.79	71.4	22.6
	After	101.3	11.4	29.5	7.74	82.9	28.77
Trial 5	Before	72.8	8.78	31.7	6.89	71.8	20.14
	After	83.2	11.98	42.5	13.01	83.2	29.78

Fig 4.11: Experimental setup near densely populated area

Graphical representation:



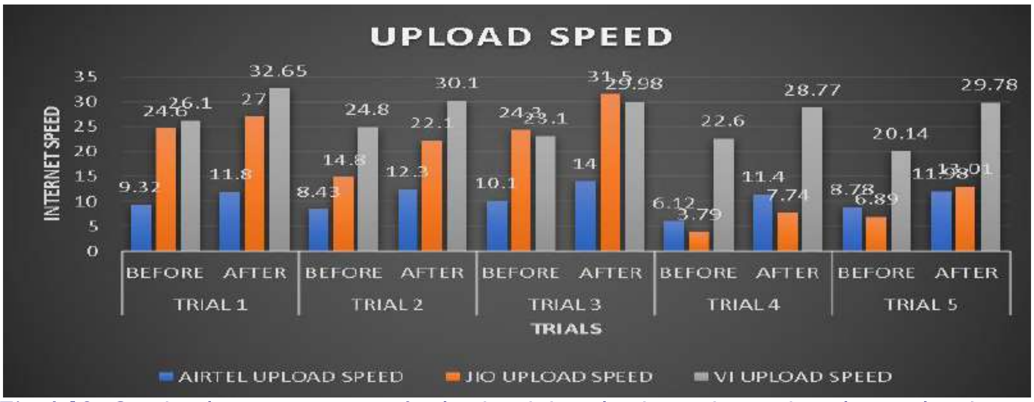


Fig 4.12: Graphical representation of upload and download speed near densely populated area

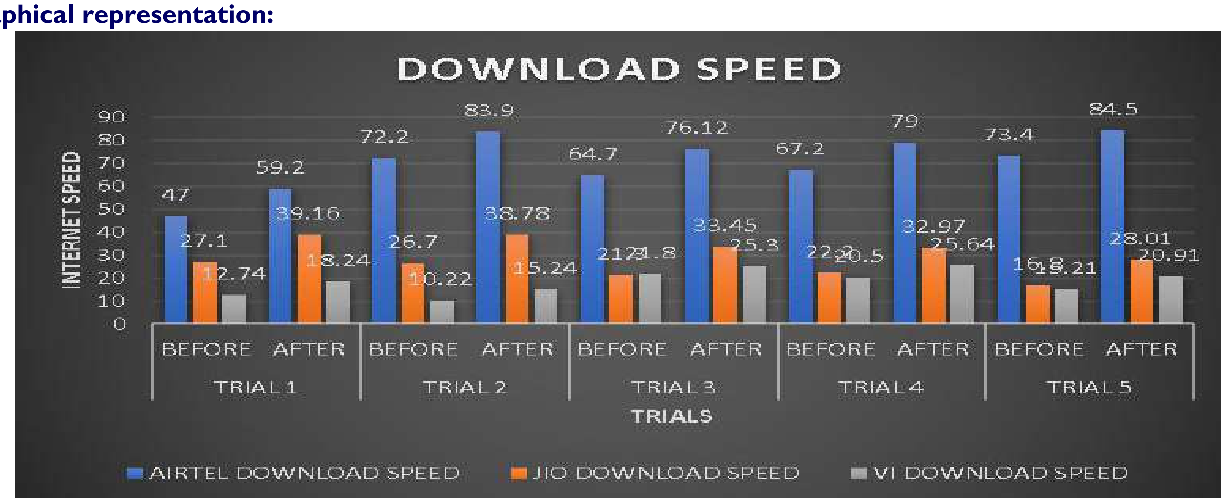
4.2.6 LOCATION: OUTSIDE NEXUS MALL, KORMANGALA

Table 4.7 Signal strength measurement near Mall

No. of Trials		AIRTEL		JIO		VI	
		Download Speed	Upload Speed	Download Speed	Upload Speed	Download Speed	Upload Speed
Trial 1	Before	47	18.3	27.1	8.16	12.74	13.3
	After	59.2	27.14	39.16	17.42	18.24	16.98
Trial 2	Before	72.2	24.12	26.7	5.83	10.22	14.9
	After	83.9	33.21	38.78	15.02	15.24	19.25
Trial 3	Before	64.7	24.8	21.3	8.35	21.8	12.6
	After	76.12	31.54	33.45	15.93	25.3	17.14
Trial 4	Before	67.2	21	22.2	8.26	20.5	11.6
	After	79	30.17	32.97	17.23	25.64	16.02
Trial 5	Before	73.4	22	16.8	8.69	15.21	14.9
	After	84.5	29.58	28.01	16.97	20.91	20.13

Fig 4.13: Experimental setup near Mall

Graphical representation:



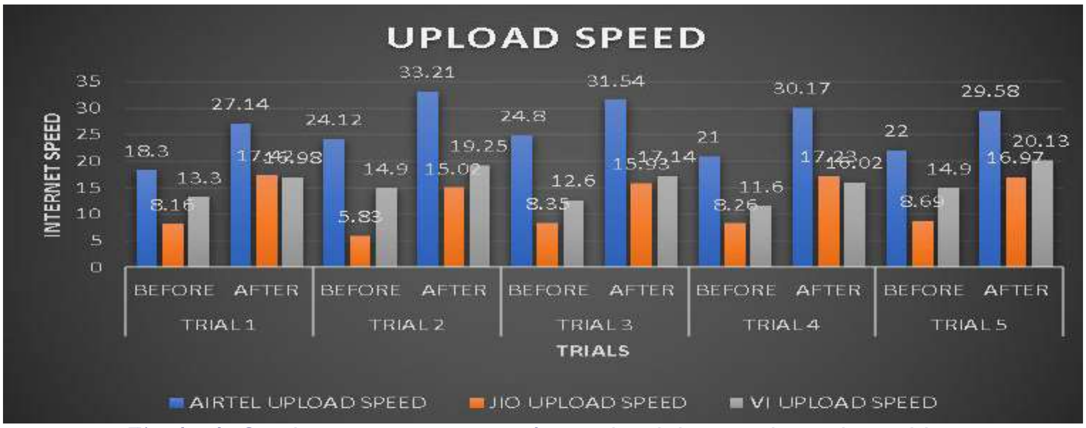


Fig 4.14: Graphical representation of upload and download speed near Mall

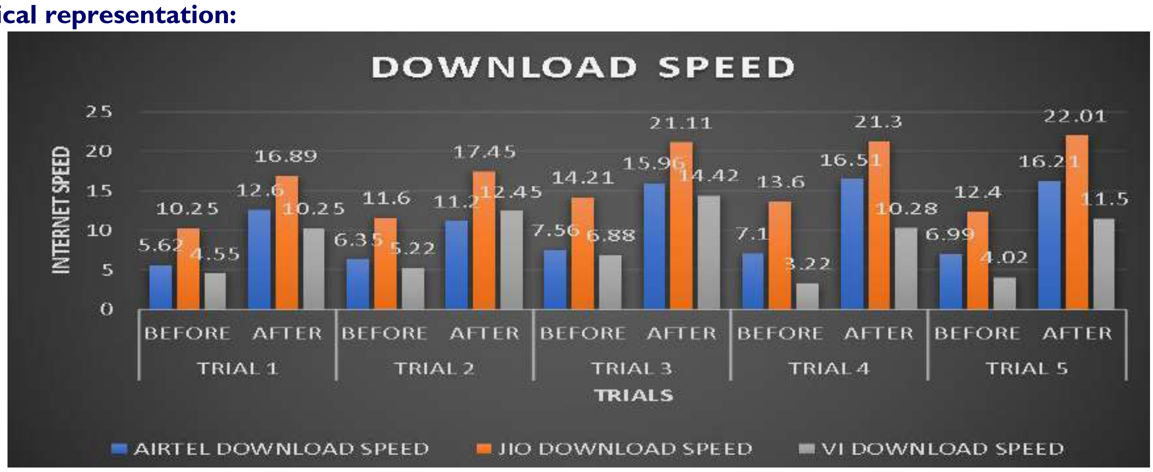
4.2.7 LOCATION: UNDER CONSTRUCTION GURAPPANAPALYA, BTM LAYOUT

Table 4.8 Signal strength measurement under construction metro station area

NO. of Trials		AIRTEL		JIO		VI	
		Download Speed	Upload Speed	Download Speed	Upload Speed	Download Speed	Upload Speed
Trial 1	Before	5.62	4.33	10.25	3.44	4.55	2.03
	After	12.6	7.89	16.89	8.15	10.25	5.31
Trial 2	Before	6.35	5.01	11.6	4.56	5.22	2.22
	After	11.2	8.21	17.45	9.98	12.45	4.94
Trial 3	Before	7.56	3.44	14.21	4.45	6.88	3.04
	After	15.96	6.22	21.11	10.2	14.42	5.46
Trial 4	Before	7.1	4.02	13.6	3.21	3.22	1.21
	After	16.51	7.88	21.3	9.95	10.28	4.13
Trial 5	Before	6.99	3.56	12.4	5.01	4.02	1.01
	After	16.21	7.89	22.01	12.6	11.5	3.89

Fig 4.15: Experimental setup under construction metro station area

Graphical representation:



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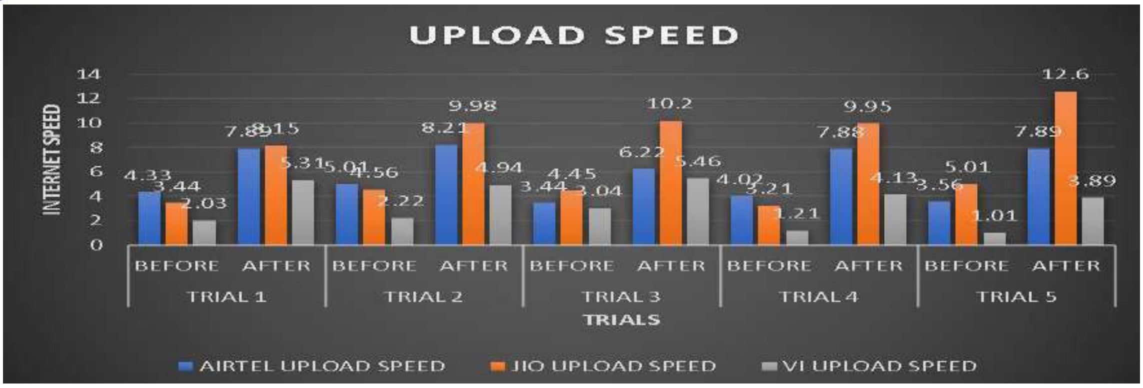


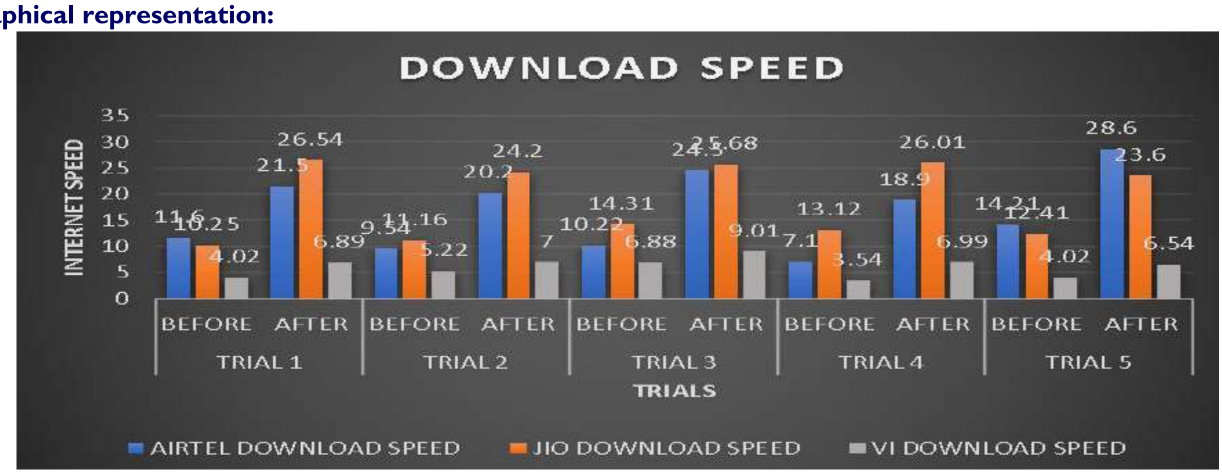
4.2.8 LOCATION: SHANTI NAGAR PARK, NEAR SHANTI NAGAR BUS STAND

Table 4.9 Signal strength measurement in garden

NO. of Trials		AIRTEL		JIO		VI	
		Download Speed	Upload Speed	Download Speed	Upload Speed	Download Speed	Upload Speed
Trial 1	Before	11.6	12.4	10.25	3.34	4.02	2.11
	After	21.5	16.5	26.54	9.14	6.89	3.54
Trial 2	Before	9.54	11.2	11.16	4.56	5.22	2.15
	After	20.2	18.54	24.2	10.21	7	4.51
Trial 3	Before	10.22	7.45	14.31	4.51	6.88	3.04
	After	24.5	14.21	25.68	11.2	9.01	5.02
Trial 4	Before	7.1	6.88	13.12	3.21	3.54	1.21
	After	18.9	13.99	26.01	12.4	6.99	3.05
Trial 5	Before	14.21	14.5	12.41	6.02	4.02	1.99
	After	28.6	21.5	23.6	13.58	6.54	3.89

Fig 4.17: Experimental setup in garden

Graphical representation:



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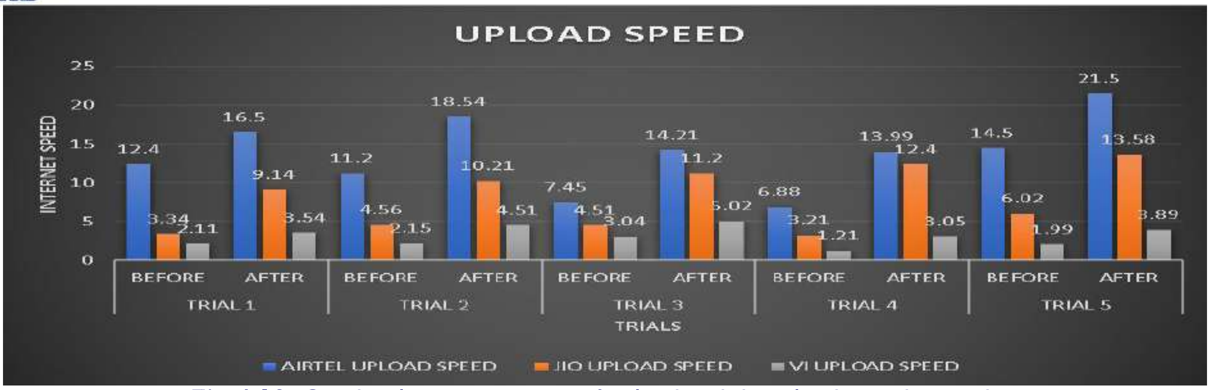


Fig 4.18: Graphical representation of upload and download speed in garden

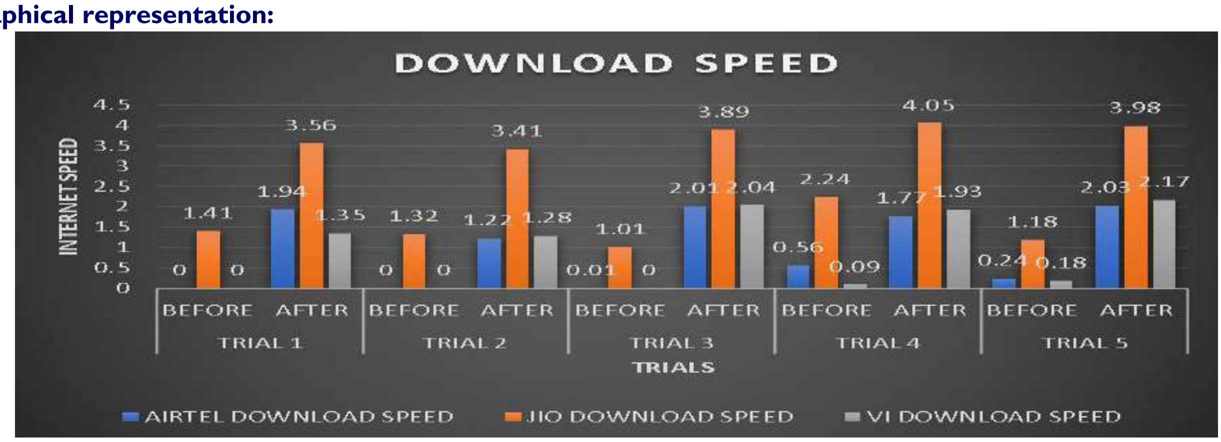
4.2.9 LOCATION: V.V HILLS, MAGADI MAIN ROAD

Table 4.10 Signal strength measurement near Hills

No. of Trials		AIRTEL		JIO		VI	
		Download Speed	Upload Speed	Download Speed	Upload Speed	Download Speed	Upload Speed
Trial 1	Before	0	0	1.41	0.56	0	0.56
	After	1.94	1.46	3.56	1.88	1.35	1.78
Trial 2	Before	0	0.01	1.32	0.45	0	0
	After	1.22	1.89	3.41	1.78	1.28	1.01
Trial 3	Before	0.01	0	1.01	1.02	0	0.24
	After	2.01	1.88	3.89	2.47	2.04	1.86
Trial 4	Before	0.56	0	2.24	0.88	0.09	0.89
	After	1.77	1.35	4.05	1.95	1.93	1.97
Trial 5	Before	0.24	0.22	1.18	0	0.18	0.48
	After	2.03	1.78	3.98	1.21	2.17	2.07

Fig 4.19: Experimental setup near Hills

Graphical representation:



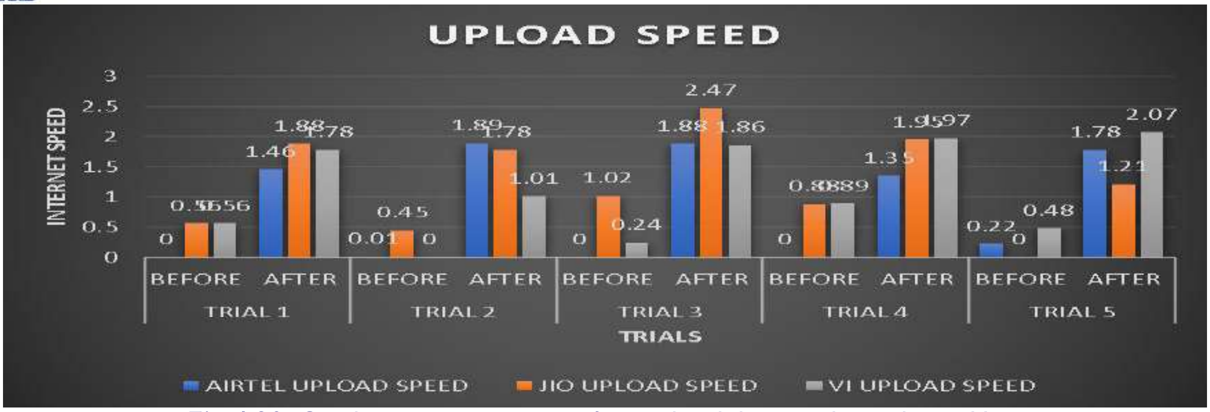


Fig 4.20: Graphical representation of upload and download speed near Hills

CONCLUSION

5.1 Conclusion

The 4G signal amplifier system utilizing an 1800 MHz Yagi-Uda antenna effectively improves signal strength and quality in areas with weak network coverage. By leveraging a directional Yagi-Uda antenna, a high-gain RF amplifier, and an omni directional antenna, the system provides the following benefits:

1. Enhanced Signal Strength:

- The Yagi-Uda antenna captures weak 1800MHz signals from distant towers with high directionality.
- The RF amplifier boosts these signals significantly, ensuring reliable reception.

2. Improved Coverage:

- The amplified signal is redistributed by the omni directional antenna, ensuring uniform coverage across all directions Within the desired area
- Better Internet Speed and Connectivity
- The amplification process reduces signal loss and improves internet speed, enabling smoother browsing, streaming, and Communication

3. Efficient Design

- The system is energy-efficient, requiring only a 5V,1 A power supply.
- The components are tuned to work seamlessly for 4Gsignals in the1800 MHz band.

5.2. Futures cope

The future scope of a4G signal amplifier using an1800 MHz Yagi Uda antenna is promising, especially in areas of low network coverage and for specific use cases. Here are some potential advancements and applications:

1. Adaptation for 5G Expansion

- Smooth Transition to 5G: The Yagi Uda antenna can be modified or optimized for 5G frequencies (e.g.,3300-3600 MHz), making it relevant as network providers migrate to newer standards.
- Hybrid Amplification: The system could support both 4G and 5G frequencies, ensuring compatibility in transitional phases where both technologies co exist.

2. Rural and Remote Area Applications

- Affordable Connectivity Solutions: A 4G amplifier setup is an economical solution to extend internet coverage in rural and remote areas, especially in developing regions where setting up towers is expensive.
- Bridging the Digital Divide: This setup could enable schools, businesses, and communities to access the internet, enhancing education and economic opportunities.

3. IoT Applications

- Enhanced IoT Networks: The system can boost signals for IoT devices (smart homes, agriculture, and health care systems) operating in low-signal areas.
- Reliable Data Transmission: Consistent amplification ensures IoT sensors and devices maintain uninterrupted communication.

4. Emergency Communication Systems

- Disaster Recovery: In disaster-prone or off-grid areas, a 4G signal amplifier can provide reliable communication during emergencies
- Portable Systems: By making the amplifier portable, it can be deployed in search-and-rescue missions or temporary setups.

5. Integration with Renewable Energy

- Solar - Powered Units: Adding solar power to the amplifier system makes it sustainable and usable in off-grid locations.
- Energy-Efficient Design: Future design scan optimize power consumption, further increasing efficiency and making it eco-friendly.

6. Enhanced Urban Applications

- Signal Strength in Dense Areas: Urban areas with high interference and shadow zones (e.g., basements, large buildings) can benefit from signal amplifiers to improve indoor coverage.
- Public Wi-Fi Expansion: Amplifier scan be used in public spaces like malls, airports, and train stations to strengthen signal quality and support more users.

7. Advanced Amplification Techniques

- Smart Amplifiers: Use of AI or machine learning to dynamically adjust the gain and frequency response based on real-time network conditions.
- Beam forming Technology: In cooperating beam forming in the YagiUda antenna to further enhance signal focus and reduce interference.

8. Military and Defense Use

- Secure Communication: The system can be adapted for secure 4G communication in remote military bases or during field operations.
- Low-Cost Deployment: The light weight and efficient design of the Yagi Uda antenna makes it ideal for portable or temporary setups.

9. Expansion to Vehicle-Based Applications

- Mobile Units: Used in vehicles to improve connectivity in moving scenarios, such as public transportation or emergency vehicles.
- Tourism and Adventure: Enhances signal availability in remote tourist spots or during expeditions

10. Support for Satellite Internet Systems

Signal Amplification for Satellite Relays: Yagi Uda antennas can be part of hybrid systems to amplify signals from satellite-based internet services, like Starlink, particularly in rural areas

REFERENCE

1. Kevin Ming Jiang Ho's Antennas for All Applications. McGraw-Hill, 2020. A comprehensive guide on antenna theory, including Yagi-Uda antenna design, radiation patterns, and practical implementations.
2. ElizabethN.Onwuka Signal Processing for 4G: LTE and LTE-Advanced. CRC Press, 2018. Carried out a study on cellular signal boosters aimed at improving network accessibility and performance in regions with poor connectivity.
3. WenRaoFang Worked in 2020 introduced a simple and universal measurement method for evaluating the efficiency of pulse RF power amplifiers
4. Saksham Jain Research in 2020 focused on the simulation and design of a network signal booster operating at 1800MHz
5. P.Kavipriya1,M.R. Ebenezar Jebarani2 , G. Jegan3 , P. Chitra4 S. Lakshmi5, 2020 4G Signal Booster: Explores the design considerations for Radio waves amplifiers used in wireless signal enhancement.
6. RF Cafe Website: www.rfcafe.com Contains calculators and design tools for Yagi-Uda antennas and RF amplifiers.2.
7. Antenna Theory Website: www.antenna-theory.com Provides tutorials and detailed explanations on various antennas, including the Yagi-Uda.