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AUTONOMOUS UAV ASSISTED WIRELESS NETWORK COMMUNICATION

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Abstract: In the ever-evolving landscape of mobile communication, the reliability of signal strength is paramount for seamless connectivity. This project delves into the realm of signal enhancement by employing the principles of signal amplification. The mobile phone signal strength reduces due to many reasons like various obstacles and distance. The proposed method utilizes the integration of a UAV and a signal booster to improve the signal strength and enhance the cellular connectivity. The proposed system provides an enhanced mobile signal to a limited area of coverage. The main component of a signal booster is a bi-directional amplifier. It amplifies signal in both the uplink and downlink directions. This allows cell phones served by the rebroadcast antennas to both send and receive data from nearby cell towers. This system can be effectively used in situations of emergency and disasters. To verify the working principle of the proposed method we utilize MATLAB as the platform for implementation. The MATLAB environment serves as a robust platform for algorithm implementation, providing a user-friendly interface for signal processing and visualization. The project encompasses the development of a MATLAB script incorporating the signal amplification Algorithm, allowing to visualize mobile signal strength enhancement. The project aims to contribute to the improvement of mobile communication experiences by providing a tool for signal optimization. The outcomes are expected to demonstrate the efficacy of UAV based signal boosting system.

Keywords: Mobile Communication, Signal Strength Enhancement, MATLAB Implementation.

I. INTRODUCTION

In the rapidly advancing landscape of mobile communication, the quality and reliability of signal strength play a pivotal role in ensuring seamless connectivity and user satisfaction. The ubiquitous use of mobile devices, ranging from smartphones to IoT devices, underscores the importance of addressing challenges related to signal fluctuations, dropouts, and overall signal optimization. This project focuses on the enhancement of mobile signal strength through the application of the signal amplification using bi-directional amplifiers (BDA). It also uses the mobility of an Unmanned Ariel Vehicle to efficiently provide the signal coverage to a limited area.

This endeavour is driven by the overarching goal of contributing to the improvement of mobile communication experiences. By enhancing signal strength through the principle of signal amplification, the project seeks to offer a valuable tool for telecommunication professionals, researchers, and enthusiasts alike. The outcomes of this project are anticipated to shed light on the effectiveness of a mobile ariel signal boosting system, with potential implications for optimizing mobile communication systems in diverse scenarios.

II. PROPOSED SYSTEM

To increase the signal strength of the mobile signal we have proposed a system that uses a bi – directional amplifier (BDA), to amplify the received weak signal and increase the transmission range and signal strength. The BDA is the main component of the amplifier unit of the signal booster. To increase the mobility of the signal booster, it is mounted on a drone as its payload (UAV). The BDA consists of a power amplifier (PA) at the transmit end and a low noise amplifier (LNA) at the receive end. A bi-directional or two-way cellular amplifier is designed to receive, amplify, and transmit cellular signals in both directions from the cell tower. Cell signal reception and transmission are done concurrently by use of a full-duplex bi-directional amplifier. It also makes use of frequency division multiplexing (FDM) or distinct broadcast and receives frequencies. Duplex filters are used by these BDAs to stop incoming and outgoing signals from interfering with one another. Gain and uplink-output power are two other variables that significantly differ between bi-directional amplifiers. These amplifiers are designed to provide a gain ranging from 20 dB (decibels) to 70 dB. From a stable position the drone-based signal booster can provide a range of 500 m to 1 km of good quality signal coverage.

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III. SYSTEM ARCHITECTURE

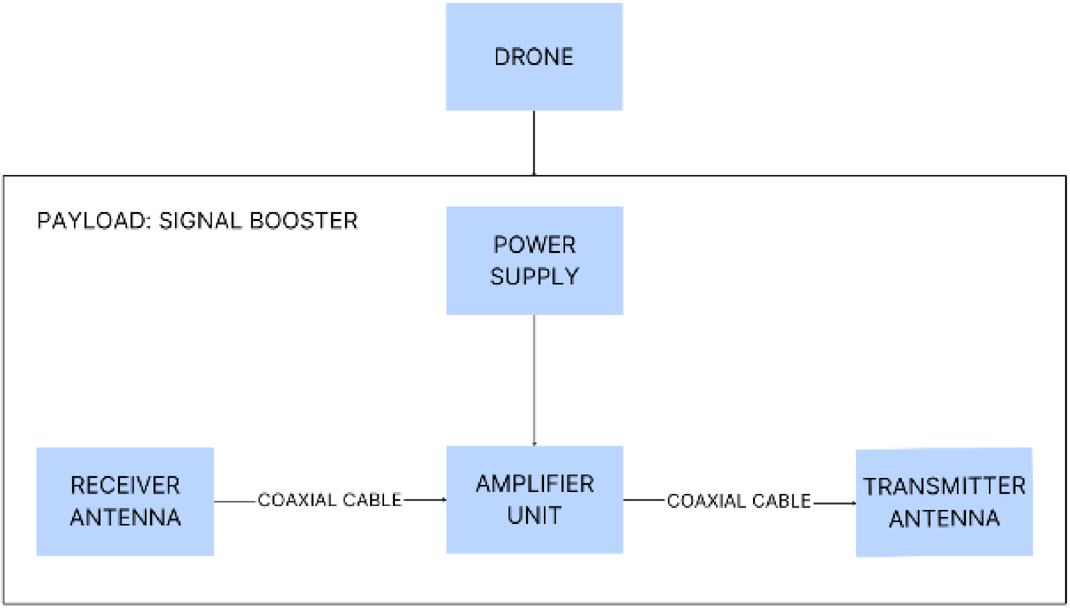

Fig. 1 Payload signal booster

The components of payload signal booster is shown in Fig. 1, amplifier unit incoming signal path is shown in Fig. 2 and outgoing signal path is depicted in Fig. 3.

1. Payload: Signal Booster

- **Receiver Antenna:** This component is used to capture the existing weak signal. The receiver antenna is usually directional, meaning it is aimed towards the nearest cell tower or signal source for optimal reception.
- **Amplifier Unit:** The amplifier unit is the heart of the signal booster system. It receives the signal from the receiver antenna, amplifies it, and then sends it to the transmitter antenna. The amplifier unit includes controls for adjusting gain and monitoring signal strength.
- **Transmitter Antenna:** Similar to the outdoor antenna, the indoor antenna is responsible for distributing the amplified signal. It is usually omni-directional, radiating the boosted signal in all directions to provide coverage.
- **Coaxial Cable:** Coaxial cables connect both the antennas to the amplifier unit. These cables carry the signal between the different components of the signal booster system. High-quality, low-loss coaxial cables are essential for minimizing signal attenuation and maximizing signal quality.
- **Power Supply:** Signal boosters require power to operate. The power supply provides electricity to the amplifier unit, in this case through a battery.

2. Amplifier Unit (BDA)

- **Low-Noise Amplifiers (LNAs):** LNAs are used to amplify weak incoming signals received by the receiver antenna. They are designed to boost the signal without introducing significant additional noise, ensuring that the incoming signal is strengthened effectively.
- **Power Amplifiers (PAs):** PAs are responsible for amplifying the outgoing signals transmitted by the omni-directional transmitter antenna. They also increase the power of the signal to ensure that it is strong enough to be transmitted back to the cell tower with minimal loss.
- **Duplexers:** Duplexers are essential components in bi-directional amplifiers as they allow the simultaneous amplification of both incoming and outgoing signals without interference. Duplexers separate the incoming and outgoing signals, ensuring that they do not interfere with each other within the amplifier unit.
- **Filters:** Filters are used to separate signals into different frequency bands. In a bi-directional amplifier, filters are often employed to isolate the incoming and outgoing signals, preventing interference between them.

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- **Automatic Gain Control (AGC) Circuits:** AGC circuits monitor the strength of both incoming and outgoing signals and adjust the amplification levels accordingly to maintain a consistent output signal level. This helps prevent signal distortion and overload in varying signal conditions.
- **Control and Monitoring Circuitry:** These components allow for the adjustment of amplifier settings and monitor the performance of the bi-directional amplifier, providing valuable feedback on signal strength and quality.
- **Heat Dissipation Mechanisms:** As with any amplifier, bi-directional amplifiers generate heat during operation. Heat sinks, fans, or other cooling mechanisms are often integrated into the design to dissipate heat and prevent overheating, ensuring the amplifier's reliability and longevity.

3. Incoming Signal Path:

- **Receiver Antenna:** Captures weak incoming signals from the cell tower.
- **Low-Noise Amplifier (LNA):** Amplifies the weak incoming signals.
- **Filter:** Filters the amplified signals to isolate the desired frequency bands.
- **Bi-Directional Amplifier (BDA):** Receives and further amplifies the filtered signals.
- **Automatic Gain Control (AGC):** Monitors the strength of the incoming signals and adjusts amplification levels as needed.
- **Duplexer:** Separates the incoming and outgoing signals to prevent interference.
- **Signal Processing Components:** Includes additional filters and equalizers for optimizing signal quality.
- **Transmitter Antenna:** Distributes the amplified signals within the building.

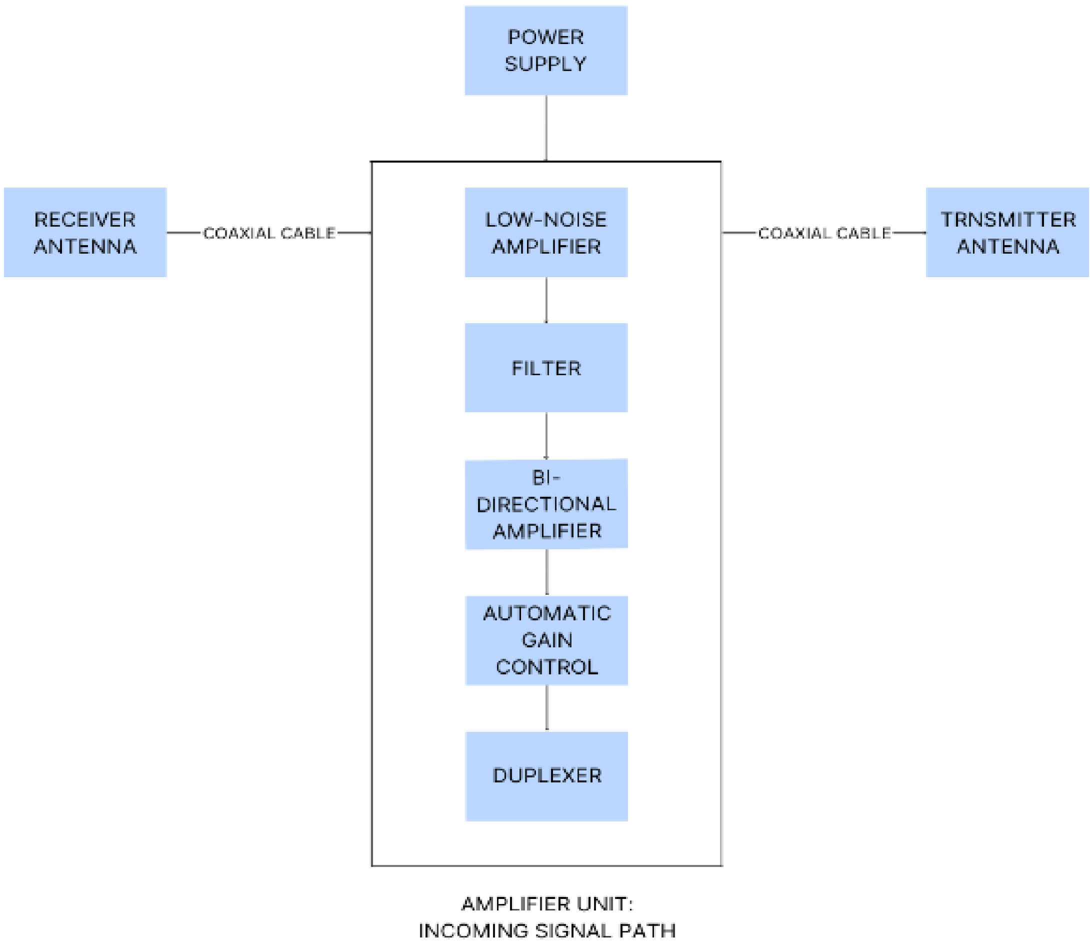

Fig 2 Incoming Signal Path

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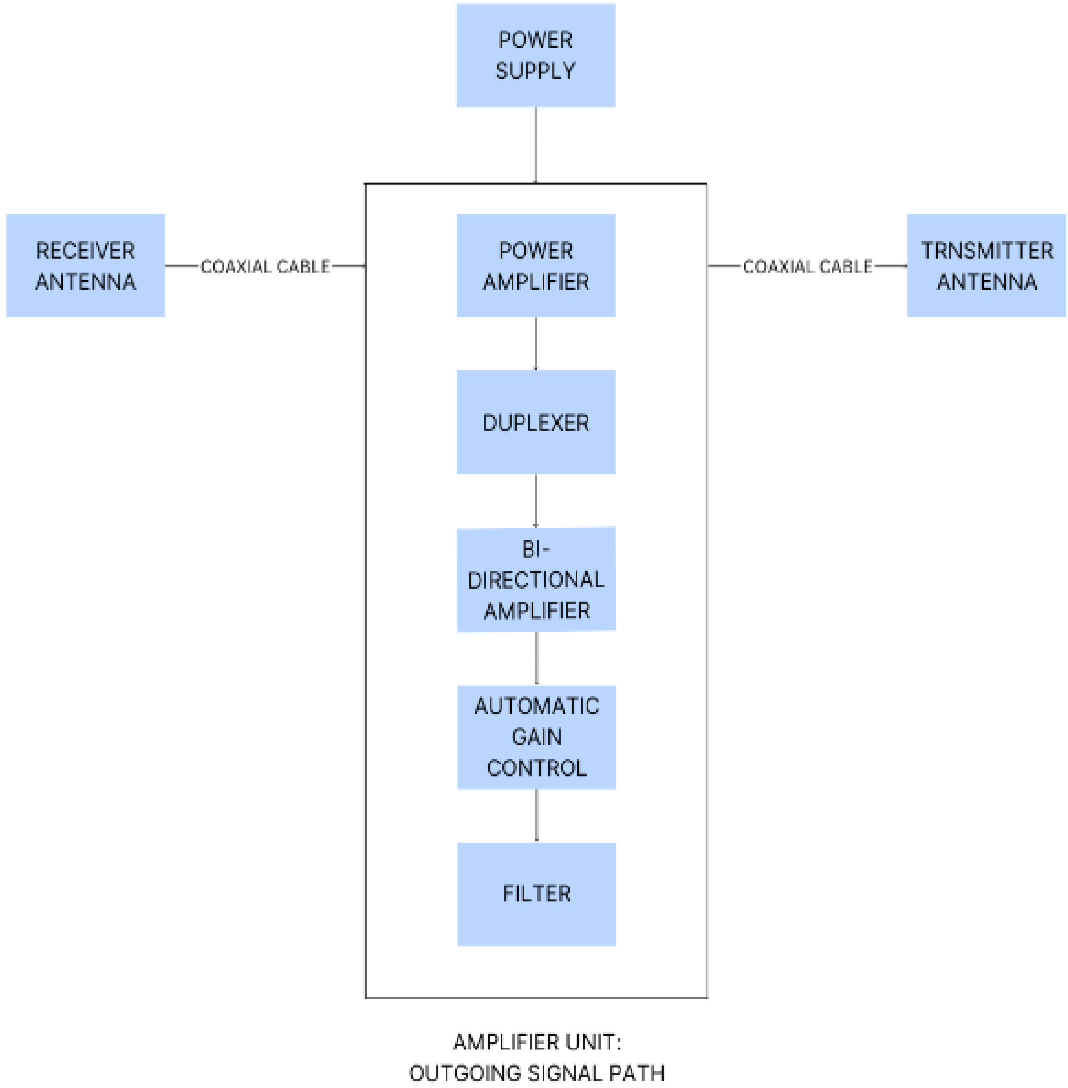

Fig. 3 Outgoing Signal Path

4. **Outgoing Signal Path:**

- **Receiver Antenna:** Transmits signals from inside the building.
- **Power Amplifier (PA):** Amplifies the outgoing signals.
- **Duplexer:** Separates the outgoing signals from the incoming signals.
- **Bi-Directional Amplifier (BDA):** Receives and further amplifies the outgoing signals.
- **Automatic Gain Control (AGC):** Monitors the strength of the outgoing signals and adjusts amplification levels as needed.
- **Filter:** Filters the amplified signals to isolate the desired frequency bands.
- **Signal Processing Components:** Includes additional filters and equalizers for optimizing signal quality.
- **Transmitter Antenna:** Transmits the amplified signals back to the cell tower.

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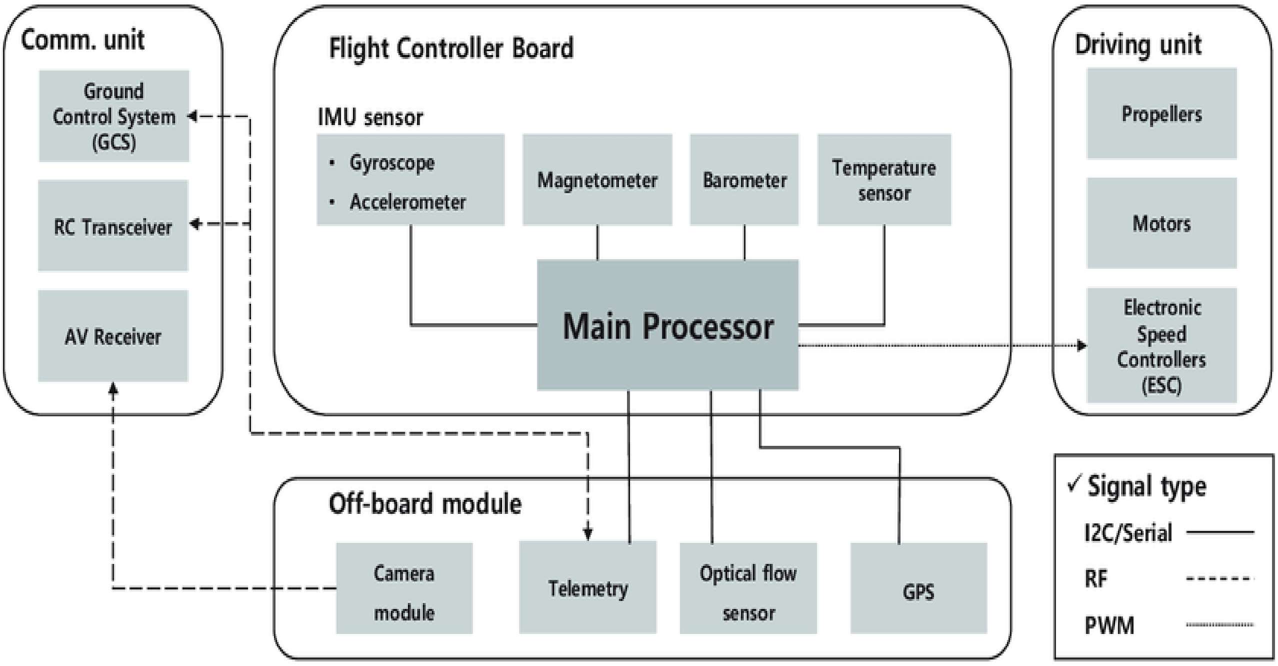

Fig. 4 Block Diagram of Drone Modules

The Fig. 4 is the block diagram which defines the working process of drone modules involves the collection of sensor data, processing of this data in the main processor to make decisions, communication with external devices or operators, and control of the drone's behaviour using the driving unit to perform specific tasks or missions.

IV. IMPLEMENTATION

The main goal of this project is to improve the throughput and connectivity of the mobile signal. In case of a power outage or collapse of the nearby cell tower the mobile signal connection is established from another cell tower which might provide a weak signal due to its distance. It can cause complications for a person. If the mobile doesn't catch the signal, it means you cannot text or call from your phone.

The weak signal from a cell tower is not optimal for efficient cell phone communication. Cellular signal strength ranges from -50 dBm (great signal) to -120 dBm (poor signal or dead zone). We are using signal booster for efficiently improving the signal range of the received weak signal. It acts as a Bi-directional Amplifier (BDA) and boosts the signal in terms of dBm gain. This signal booster is mounted as the payload in a heavy lifting cargo UAV to enhance the mobility of the signal booster. The signal booster and the UAV are powered by rechargeable battery and has a dedicated charging station.

The signal booster amplifies the weak signal thus improving the downlink and uplink connectivity. The signal booster is able to provide few thousand sq. ft of improved cellular connectivity. Thus, providing a temporary reliable communication medium until the cell tower is repaired. The output of the proposed system is verified by a simulation performed in MATLAB. The obtained graph shows that the original signal when passed through the signal booster becomes the enhanced signal and has a noticeable gain in signal strength (dBm).

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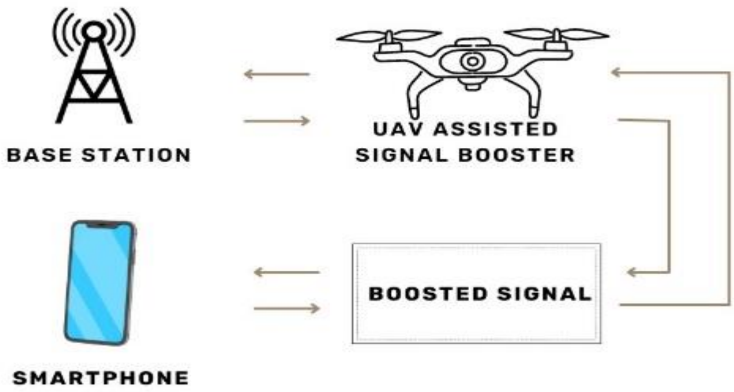

Fig. 5 System Flow Diagram

The Fig. 5 diagram represents the signal flow from the base station to the UAV assisted signal booster, where the signal strength is boosted and sent to the smartphone.

V. RESULT AND DISCUSSION

We have visualised the results of the enhanced signal from the signal booster and to show comparison between the normal signal transmission of 2G, 3G, 4G and 5G with the enhanced signal transmission from our proposed system of drone-based signal booster. The graph is generated using MATLAB which represents the signal to distance ratio of the signals.

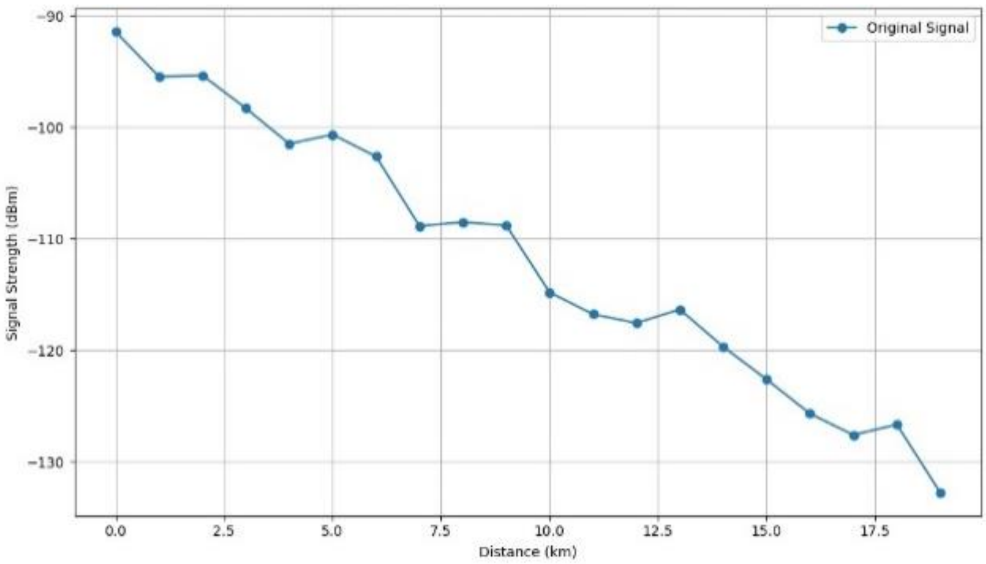

Fig. 6 2G Signal Strength Simulated in MATLAB

The Fig. 6 graph shows the simulated result of the 2G mobile signal strength from a cell tower.

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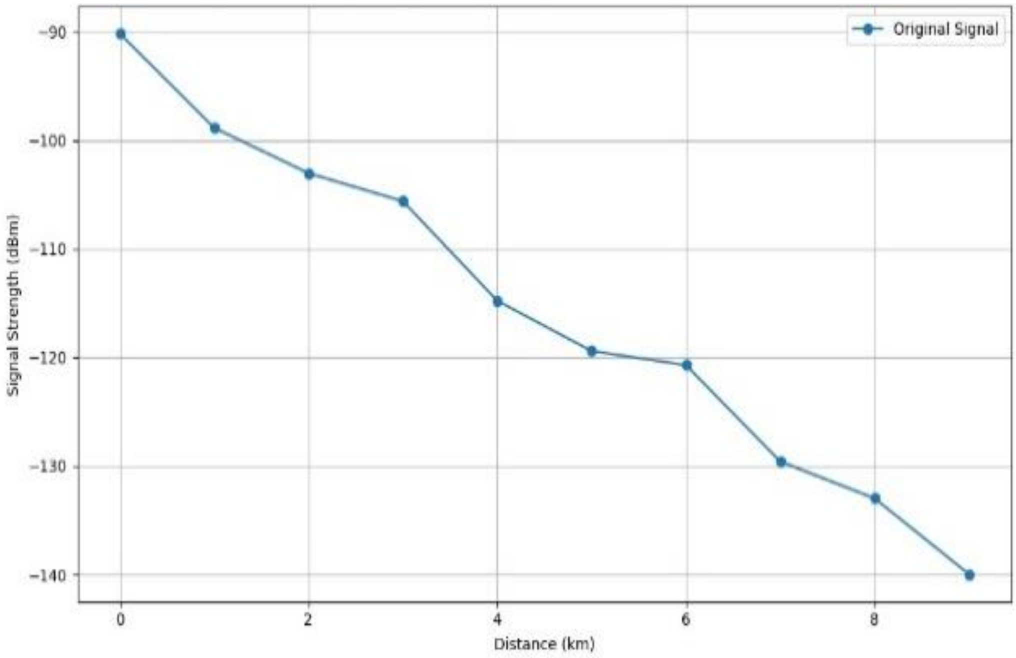

Fig. 7 3G and 4G Signal Strength Simulated in MATLAB

The Fig. 7 graph shows the simulated result of the 4G mobile signal strength from a cell tower.

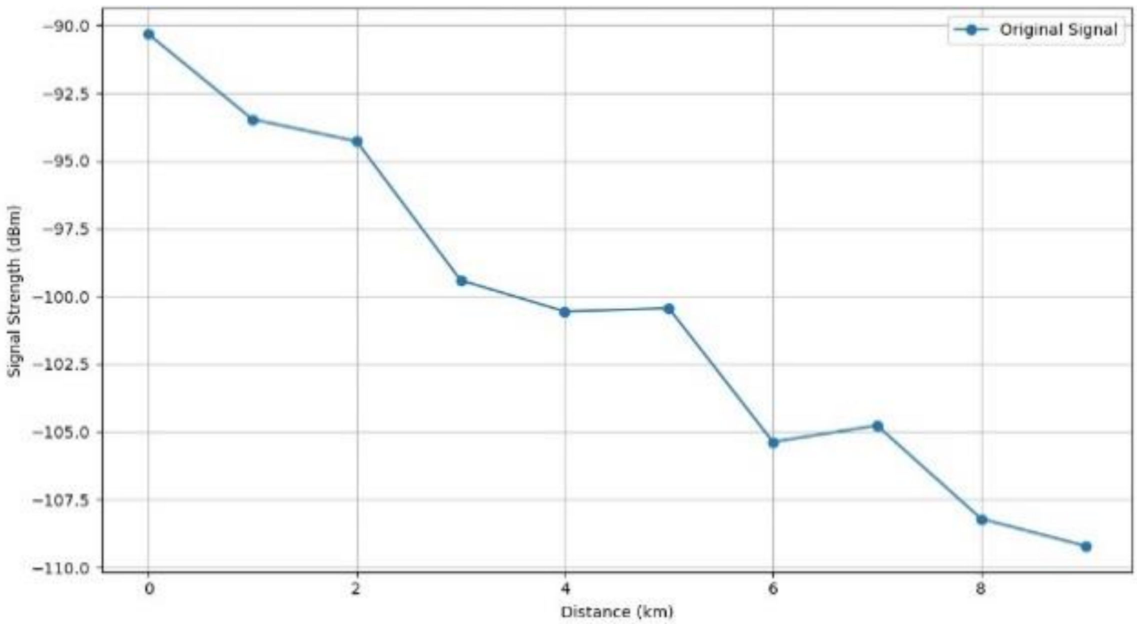

Fig. 8 5G Signal Strength Simulated in MATLAB

The Fig. 8 graph shows the simulated result of the 5G mobile signal strength from a cell tower.

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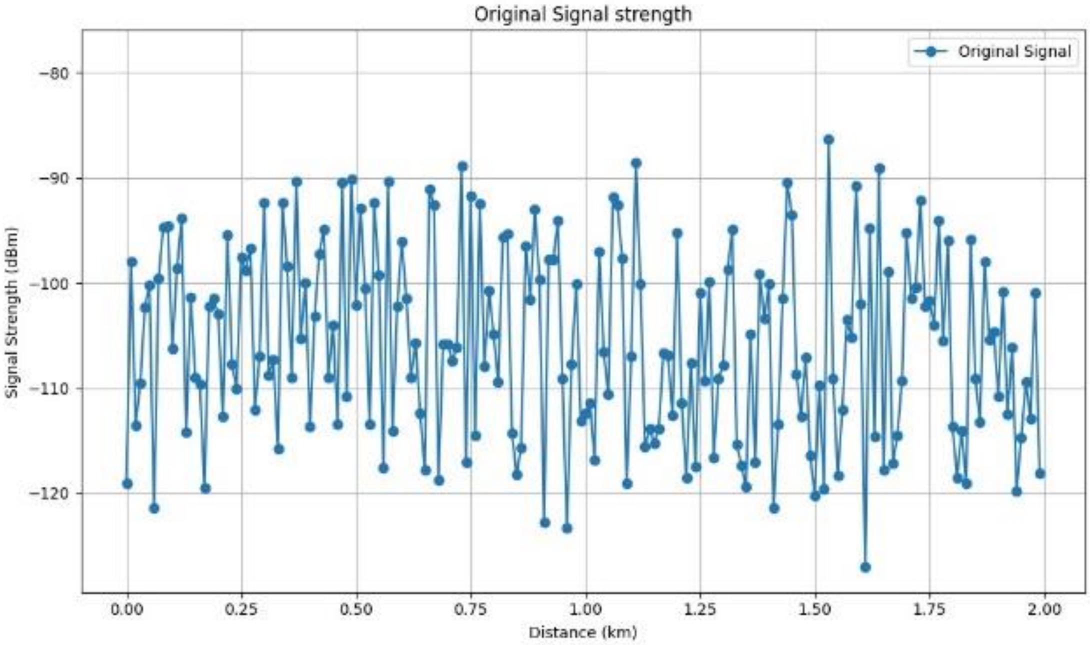

Fig. 9 Original Signal Strength Simulated in MATLAB

The Fig. 9 graph shows the simulated result of the mobile signal strength from a cell tower to the cell phone without boosting, in terms of power in decibel milliwatts and distance in kilometres.

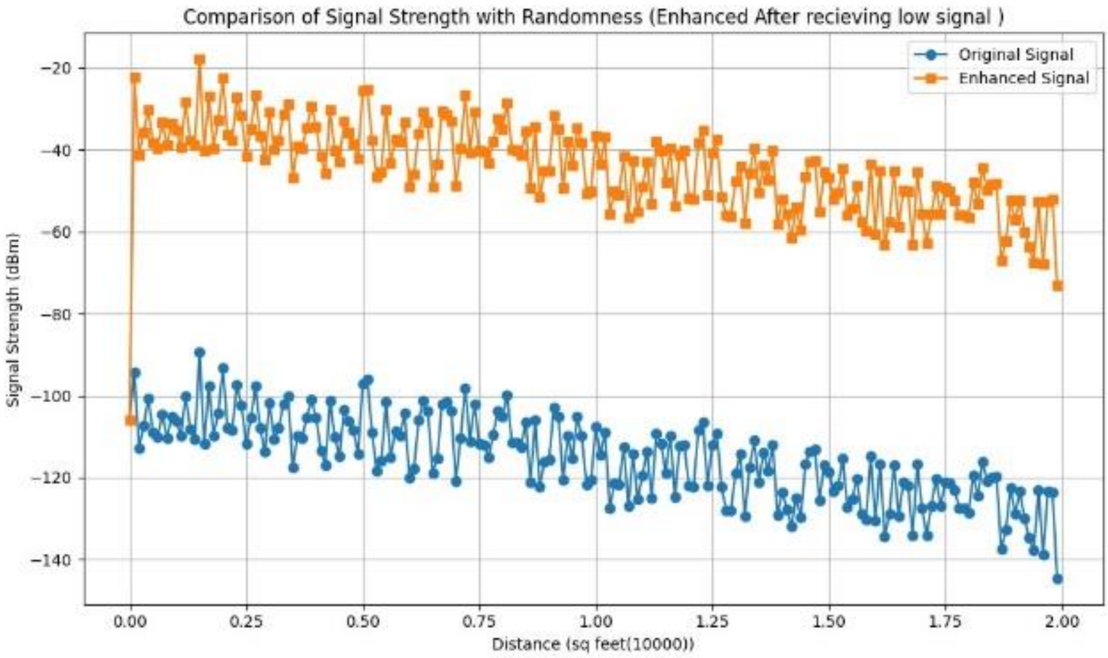

Fig. 10 Enhanced Signal Strength Simulated in MATLAB

The Fig.10 graph shows the simulated result of the mobile signal strength from a cell tower to the cell phone and compares it with the signal from the drone-based signal booster with enhanced signal strength. in terms of power in decibel milliwatts and distance in kilometres. Here the gain of the propose system is 40 dB to 70 dB, so the enhanced signal has a much higher dBm. Thus providing a better signal strength.

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VI. CONCLUSION

Our proposed system can be improved by making the drone (UAV) autonomous and providing it with an intelligent system. By the development of a MATLAB script incorporating the Grey Prediction Algorithm, allowing users to enhance mobile signal strength through predictive modelling. The project aims to contribute to the improvement of mobile communication experiences by providing a tool for signal optimization.

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