UNIVERSITY OF NOTRE DAME

5G Repeater

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Project Overview

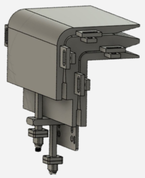
Low-emissivity glass used in modern homes and businesses can impede delivering 5G connectivity to users indoors. Low-e glass is designed to insulate homes by minimizing the amount of infrared and UV light that comes through the glass. Unfortunately, high frequency 5G mmWave signals can be reflected from the low-e coating on the glass, resulting in a weak in-building signal. Therefore, there is a need for a 5G repeater mounted on the inside of a window to amplify services from a 5G base station into a user's home inexpensively.

Future networks intend to incorporate more low earth orbit (LEO) satellite communication systems to provide wide band internet access to residential areas. Current beamforming technologies require a large array of antennas and are subsequently very expensive. Using Dr. Garcia and Dr. Chisum's novel lens antenna prototype, a simple, linear feed antenna can be used in series with GRIN lenses to beamform inexpensively and passively without sacrificing performance.

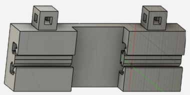
System Requirements

1. Move the lens antenna with a stepper motor and store its location and signal strength.
2. Convert RF input into a digital value using the power sensor and A/D converter.
3. Display how powerful the signal is using an LED.
4. Scan the entire length off the lens and algorithmically determine the optimal location for reception.

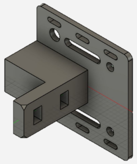
CAD



Parallel plate waveguide with feed antennas

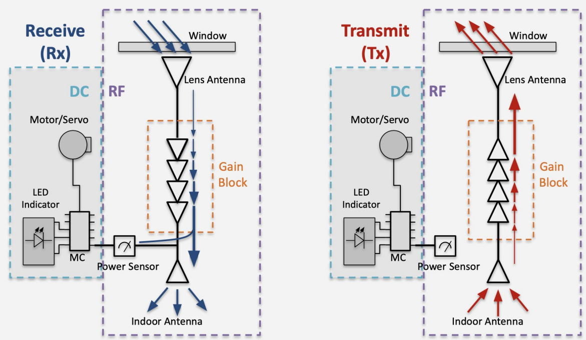


Linear rail mount



Linear rail plate with feed antenna mount

Subsystems



- The ESP32-WROOM-32E **Processor** accommodates communication between the power sensor, motor driver, and LED display.
- A **Feed Translation Mechanism** controls the feed antenna to scan across the entire range of the device and determines the optimal position based on the maximum input signal.
- **Individually addressable LEDs** display the strength of the signal using the WS2812 protocol.
- The LTC5596 **RMS Power Detector** outputs a DC voltage between 0 and 1.2 V to represent the average signal power applied to the RF input.
- A 3D-printed **Parallel Plate Waveguide** lined with copper guides the propagation wave from the GRIN lens to the feed antenna.
- An **Indoor Antenna** is used to propagate the amplified outdoor mmWave signal in an indoor environment.
- The **Gain Block** amplifies the transmit and receive signals.

Future Enhancements

The initial demonstration for this project will focus on a controlled stationary 5G base station that will employ static beamforming to provide a fixed radiation pattern. Upon successful demonstration of the system, the project can be enhanced to utilize adaptive beamforming to account for LEO satellite movement. As the position of the satellite changes, the system will dynamically change to measure and store power readings to find its optimal feed position.

Control Board

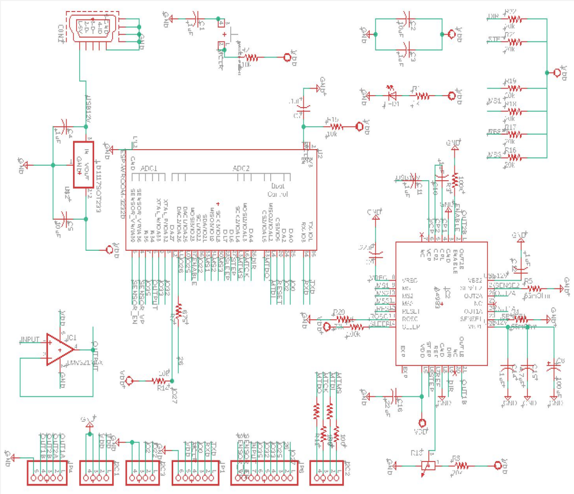


Figure 1: Schematic

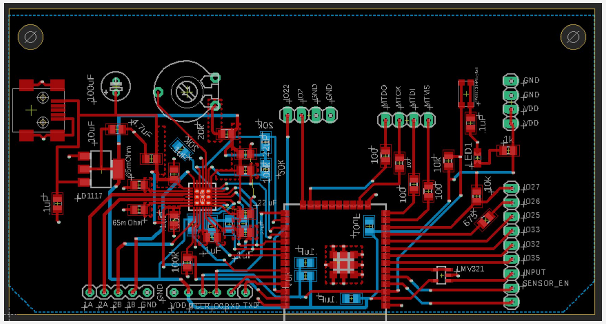


Figure 2: PCB Layout