BANGOR UNIVERSITY 2021

LASER BASER FREE SPACE COMMUICATIONS

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INTRODUCTION

Laser baser free-space optical communication (FSLC)is a method of sending messages wirelessly using the light transmitted from a laser which is being turned on and off to convey the message.

In this project I designed and tested a system that can create a data package, transmit the data through a laser, receive the data and then measure the accuracy of the system by comparing the incoming data to the send data and adding up the miss matched bits of data.

BACKGROUND

FSLC is has been tested at distances of 385,000km in free space from the moon to earth and has been sent at speeds of up to 10 Gbit/s in other tests.

Because it can travel huge distances, communicating large amounts of data at pretty much the speed of light, it is a promising technology. That may replace some of the traditional communications systems currently used in the space industry.

METHODOLOGY & APROACH

- A pseudo random bit sequence (PRBS) is generated and send out of the Field programable gate array (FPGA)
    - A PRBS is a data set that contains every possible combination of values that can be represented by the number of bits that it's made of. For example, a 2-bit PRBS would hold the values (00,01,10,11)
    - The FPGA is a device which acts like a computer, the brains of the operation.
- The data is processed by the transmitter circuit to deliver the correct voltage and current to the laser
    - The laser has a threshold voltage and an operating voltage. You could use the operating voltage for a high and zero volts for low, but this would take a relatively long time to do. Instead it is much faster to let the voltage rest at just below the threshold voltage for the low position. Increasing the speed of the laser to turn on and off.
- light travels from the laser through the air towards the photodiode.
- The light hits the photodiode which creates a voltage that is equivalent to the power level of the light
- The signal from the photodiode is amplified by the receiver circuit for it to be more easily read by the FPGA
- The FPGA counts how many errors the system made and that number is displayed by the LEDs

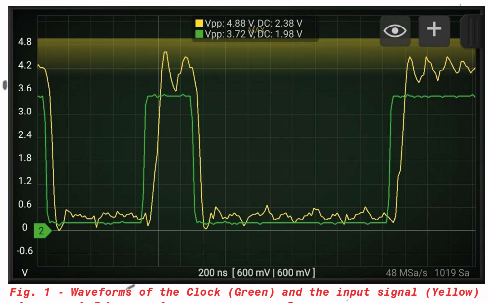

Fig. 1 - Waveforms of the Clock (Green) and the input signal (Yellow)

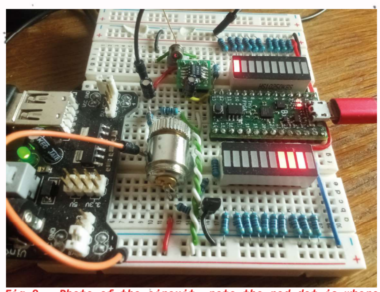

Fig.2 - Photo of the circuit, note the red dot is where the laser is hittin ghte photodiode.

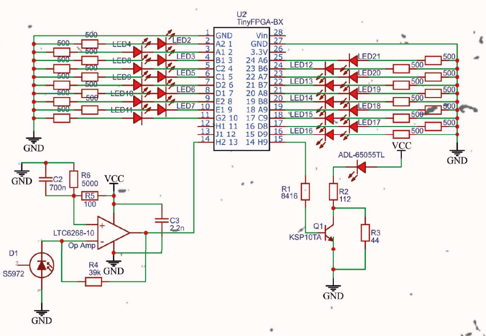

Fig.3 - The Circuits schematic

RESULTS

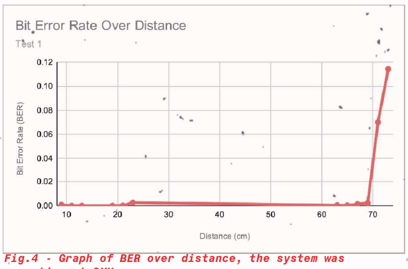

Fig.4 - Graph of BER over distance, the system was operating at 2MHz.

The graph in Figure 6 shows the bit error rate (BER) over Frequency at a distance of 3cm, it shows that the system works with an acceptable BER (0.001) at speeds up to and including 2.6MHz and then quickly becomes unusable as the frequency is increased above that.

In Figure 5 we have a graph of the BER over the different angles the laser was hitting the photodiode. The only time there was a bit error was at 63.4 degrees where half the laser was hitting the photodiode case meaning that at any angle with a direct line of sight had an acceptable BER.

The BER was measured over different distances and graphed as shown in Figure 4. This graph shows how the system can operate with an acceptable BER of 0.001 at distances up to 69cm. Anything above 69cm becomes unusable, this is because the light is defusing causing the area of the beam to become bigger than the area of the photodiode.
This means the photodiode is only receiving a fraction of the transmitted power.
This can be improved by using a second culminating lens in front of the photodiode to focus the light, shrinking the surface area back to a size the photodiode can accept.

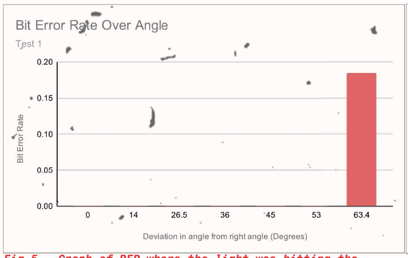

Fig.5 - Graph of BER where the light was hitting the receiver at different angles.

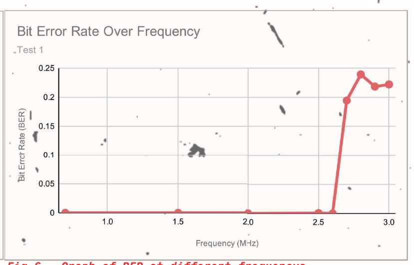

Fig.6 - Graph of BER at different frequencys

AIMS & OBJECTIVES

- Study the associated FSO technology (lasers, photodiodes, atmospheric propagation of light).
- Study the associated commercial applications and current research work.
- Design, build and test a laser-based free space optical communication demonstration system that can transmit up to a meter at 1Mbps.

CONCLUTIONS

Looking at the results from the first round of testing it is clear that it's possible to achieve much faster bandwidth than 1Mb/s already reaching 2.6Mb/s with many more techniques yet to implement to improve on this further. When It comes to distance the system on its first test falls short of the one meter goal by 31cm but preliminary testing shows that using a second culminating lens could achieve distances up to 2.5 meters.
Not knowing what to expect and having no goals with respect to the angle of the photodiode compared to the incoming beam, the testing shows that it performs optimaley regardless of the angle. A further test could be to repeat the test at a higher frequency for example 2.6MHz.