Point to Point Laser Communication

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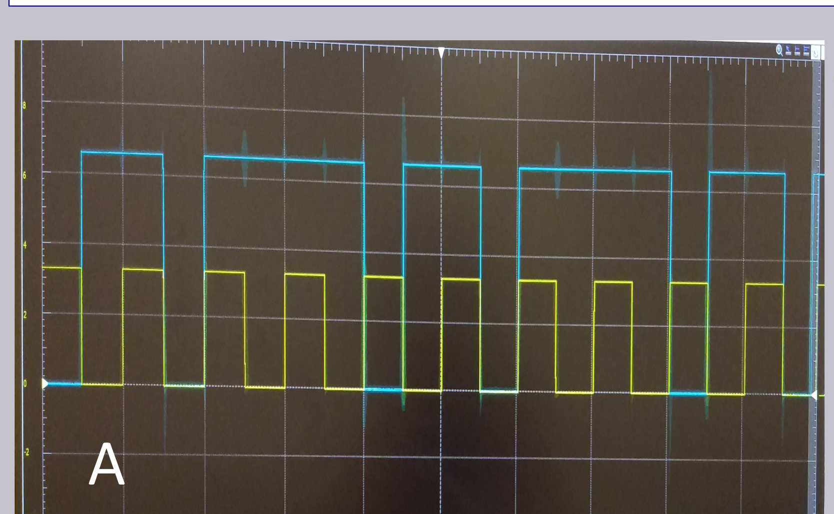
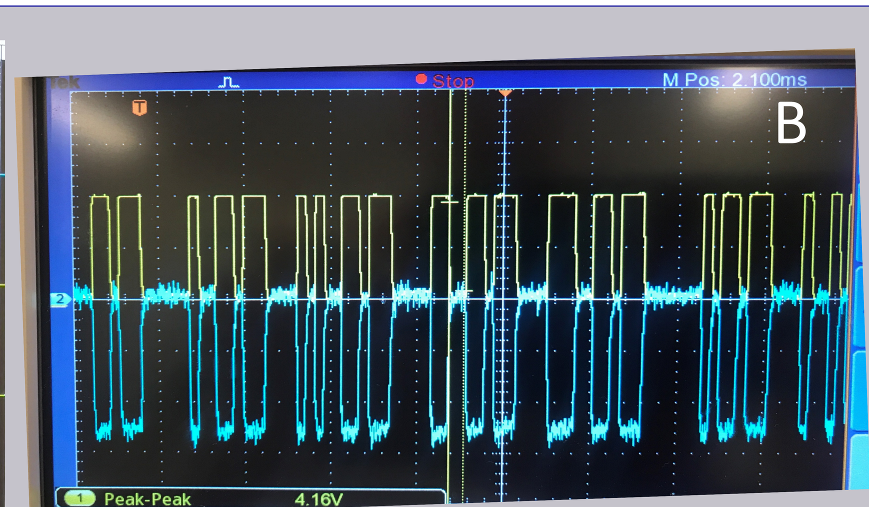
Introduction:

With an increasingly connected, digital, fast paced world the need for highly secure and/or readily available large bandwidth data transmission is greater than ever. Currently, wireless technology is being broadcasted over the radio spectrum. This spectrum is filled from 3 kHz to 3 GHz with no extra bandwidth open These needs can be met with light-based communication systems, also known as Light Fidelity (Li-Fi). A strong source of additional spectrum lays in the 405 THz to 790 THz range, more than 120,000 times larger than the allocated radio spectrum. This spectrum consists of the visible light spectrum, being utilized by light emitting diodes (LEDS) all around us. This design is not intended to be a full fledge Li-Fi system. It is an open-air point-to-point data transmission system using lasers in the visible light spectrum, operating at 650 nm (red light). This design demonstrates the use of light in the communication field by reaching data transmission speeds of at least 5 kb/s, creating the foundation for furthering speeds.



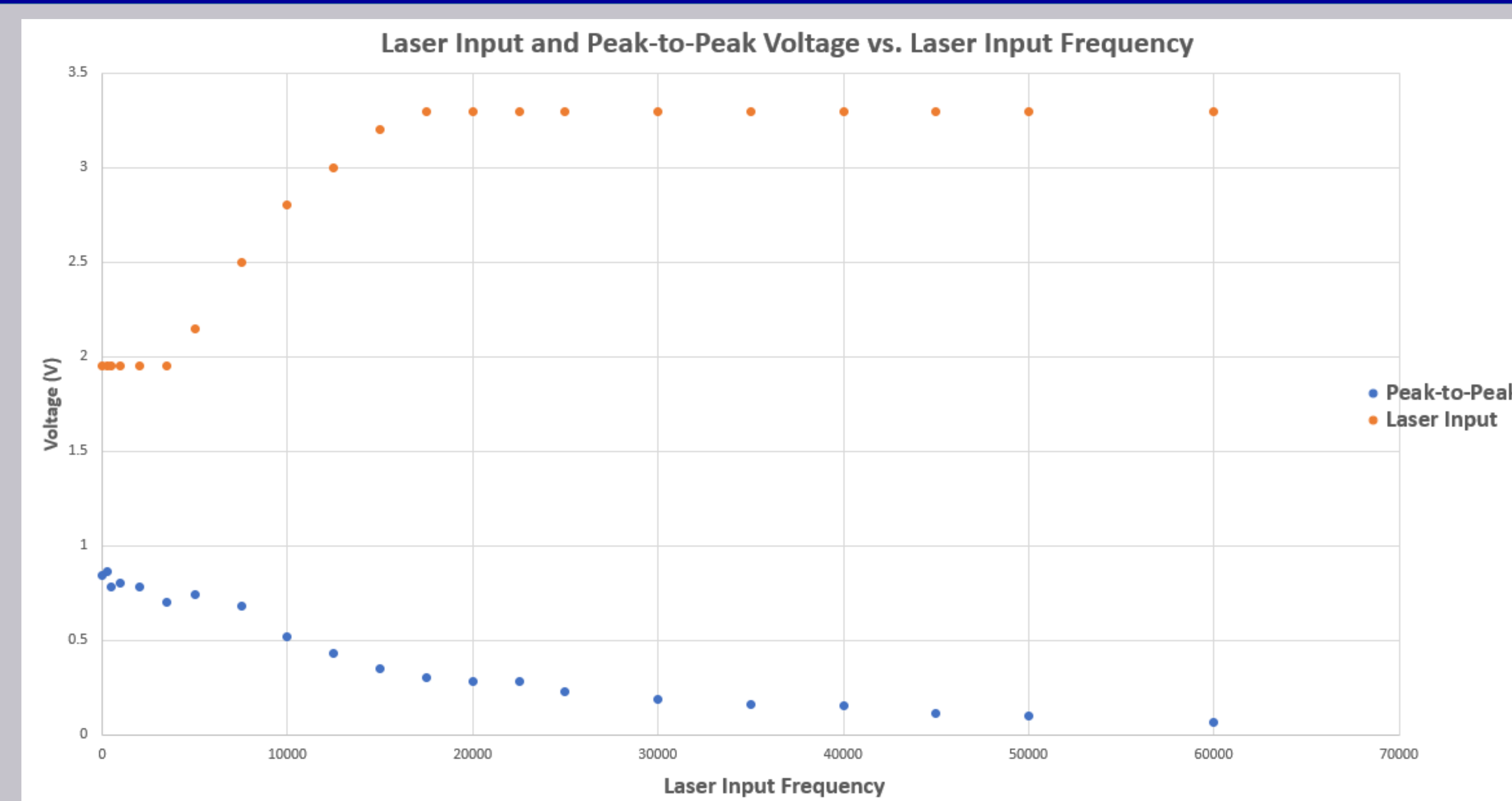


Materials and Methods:

The software used for this project were:
- STM CubeMX
- ST-Link
- Keil MicroVision
- Wavefroms

The major components used in this project were:
- Two Dual Core Microcontroller - STM32H747I-Disco
- Two LED lasers - LC-LMD-650-01-01-A
- Photodiodes - BPX 65
- Transimpedance amplifiers - OPA656U/2K5
- BJTs - 1514-2N2369APBFREE-ND

The testing methods used in this project were:
- GPIO output voltage level was tested with oscilloscope measurements
- The quality of the output from the photodiode was tested with a square wave in put from the laser at frequencies of 10Hz, 100Hz, 1kHz, 2.5kHz, 5kHz, 10kHz, 100kHz.
- Current output from the GPIO pins to the laser driving circuit was measured with an ammeter.
- Accuracy of correct bit sent was measured by counting and displaying when the next bit read was out of order.



Results and Discussion:

- The STM32H747I-Disco is a fairly new board to the market, so the first step was establishing correct .hex flash to the board.
  - A bug was found in STMs newest flash software, so the older ST-link was used
- With the laser generating a square wave at 5kHz measurements of the output of the photodiode was taken on an oscilloscope.
  - The "cleanness (most similar to the input)" of the output wave was discovered to be a function of distance, voltage input to the laser and frequency.
- With the optimal voltage known for a set distance at a range of frequencies*(shown above)* the output waveform could be improved upon by the receiving circuit.
- A Schmitt trigger was added to the receiving circuit to produce a sharper transition, or a squarer wave output.
- An inverting amplifying opamp was added to produced a waveform with voltage values within the accepted digital range for the STM32H747I-Disco
- The microcontroller was programed to generate an output based upon an internal clock. Figure A shows 6F with the output(blue) based upon the clock signal(yellow).
- With the receiving and driving circuit working well and known values for voltage at desired frequency, integration began.
- An initialization sequence was used to sync the sending and receiving clocks of each microcontroller with data flowing after that initialization. Figure B shows the input from of the laser in blue with the output of the receiving circuit in yellow.

Conclusion:

Our team has created a point to point laser communication system using a single laser operating at 650nm. We created a system that was accurate operating at 11 kb/s. This design works at a distance of 30 feet and can be bounced of off mirrors to transmit data around corners. The data is displayed by an array of LEDs indicating either the last byte that was received or the number of times the microcontroller had received a sequence of 0 – 255.

Future Work:

The following are ideas to further improve the point to point laser communication project:
- Continue research on clock synchronization.
- Data encoding for efficient information transfer, like packets of the internet or wifi.
- Testing to increase speeds and monitoring the error rate.
- Displaying data transfer in a user-friendly way (live drawing on the touch screen).
- Sending information dense objects like videos or photos.

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