Naval Postgraduate School

EC2200 Final Project

Solar Cell Optical (Laser) Communication

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Purpose

The purpose of the lab project is to test the feasibility of using a laser to transmit into free space for optical communication. Using a transistor we will modulate a signal and attempt to receive it at a distance using a solar cell and a series of transistors. This project has broad application specifically to the Cube Satellite project allowing dual use of solar panels as both power generation devices and communications devices.

Description of Experiment

1. We used a high efficiency Triple-Junction with Monolothic Diode solar cell to receive the laser communication. The Performance data is shown in Figure 1.

Solar Cell Area = 26.6 cm^2

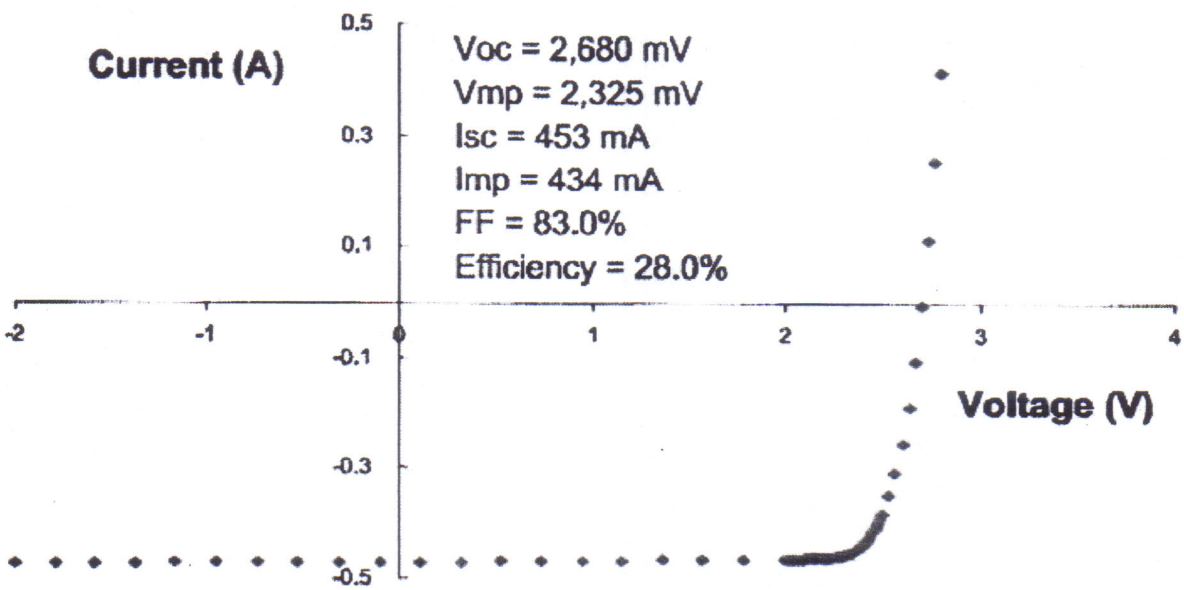

Figure 1: Solar Cell Specs

2. The transmitter circuit, seen in Figure 2, allowed us to use the high speed switching of a 2N3904 transistor in order to modulate the laser diode to the desired frequency.

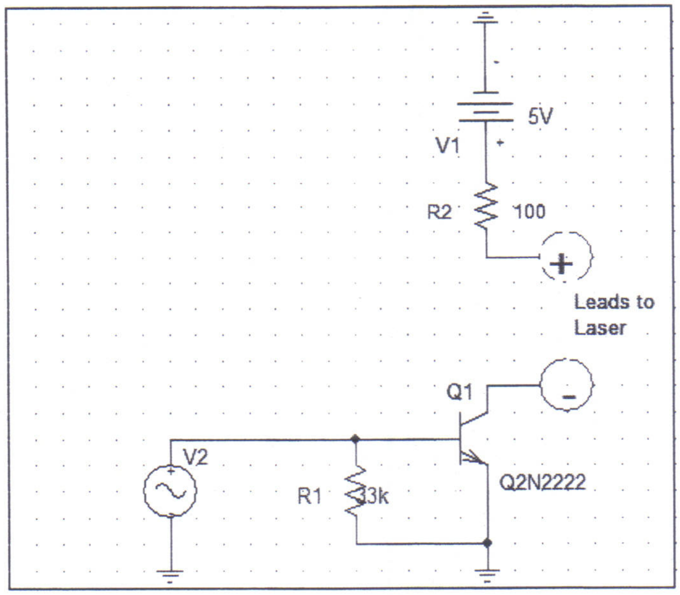

Figure 2: Transmitter Circuit

3. Figure 3 is a schematic of the Receiving circuit. A capacitor was placed in line with the 5V DC power supply to filter out noise and ensure a clean output signal. Our circuit was biased based on the assumption that the laser communication would be taking place on a solar panel that is not charging from sunlight. In order to simulate this we placed a piece of cardboard over the solar cell with a small hole for the laser to shine through. Our receiver configuration will not support communication while a solar cell is in contact with sunlight because it will saturate the transistors.

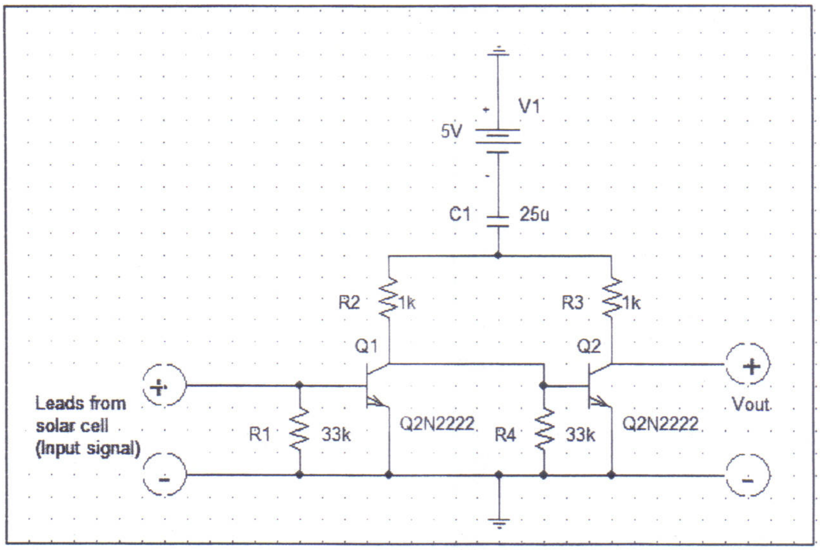

Figure 3: Receiver Circuit

Results Description

1. Figures 4 thru 15 show the output of our receiver circuit before we put the filtering capacitor in. The transmitted signal varies in frequency but is a square wave, 50% duty cycle. Our output duty cycle is not quite 50% as we increase the frequency on the transmitter. This is most likely due to the fact that the solar cells have some internal capacitance and act as a battery when there is no light to charge.

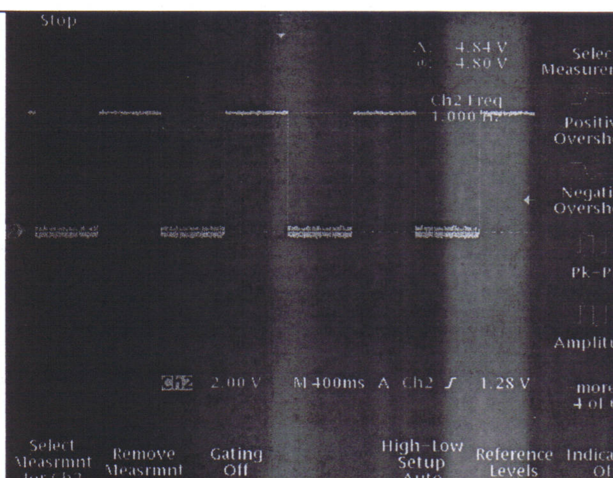

Figure 4: 1 Hz

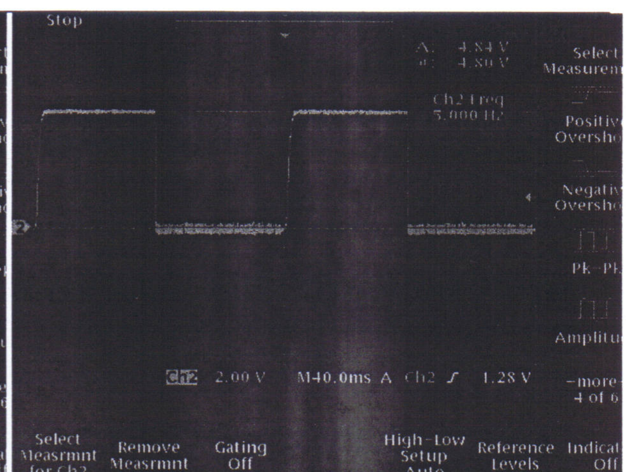

Figure 5: 5 Hz

Conclusions

1. We were able to successfully transmit a 688 KHz signal to the receiver and up to 5 MHz without the cover. Future work can be done to improve our design and potentially improve the transmission rate. We experimented a small amount with the possibility of AC coupling the signal into the receiver an amplifying it as opposed to taking advantage of the switching property of transistors. Using this method would eliminate the requirement to communicate with only the solar cell that is not illuminated.

2. Initially we thought that there was an internal switching circuit in both the red and green over the counter lasers. After using the spectrum analyzer, we discovered that only the green laser has this circuitry. Therefore, AC coupling the red laser into the receiver and using a series of transistors to amplify the signal should be an effective and more reliable method of optical communication via solar cells.

3. We also recommend in the future setting up the experiment with the green laser and running further tests to see if it is possible to get more output. Additionally it is recommended if possible to get access to a signal generator that output at greater than 5 MHz to see it it achievable to increase the data rate more.