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A Visible Light Communication System

Introduction

In this project, we are going to design a basic communication system which transfers information by using visible light. What we want to achieve is that after giving a message to the system as an electrical signal, we will transform this signal into visible light, and then the emitted visible light will be detected by a detector, and finally the corresponding message will be displayed after processing the received signal. We will do this by constructing a system consisting of two parts, which are the transmitter part and the receiver part.

Design Overview

The two parts of the system is shown as a simple block diagram in Figure 1.

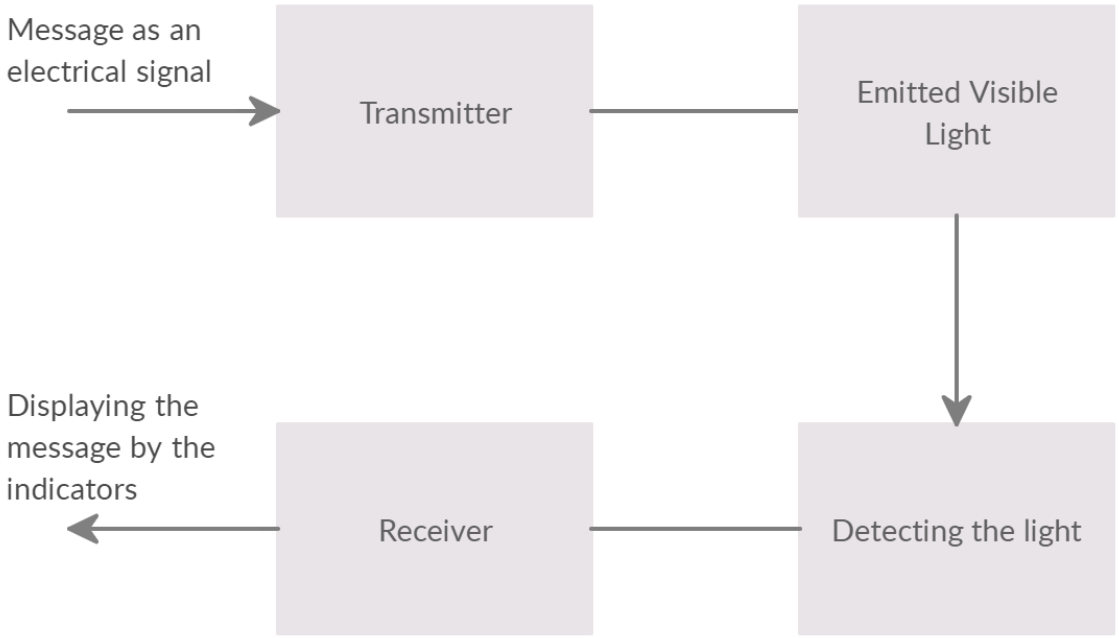

Figure 1: The overview of the general system

Firstly, an integer number from a finite set will be determined as a message. Then, according to this message, which is a number, an electrical signal will be generated on the transmitter part. The frequency of the generated electrical signal will be adjusted according to the number that the corresponding message represents. After that, the electrical signal will be transformed into visible light by using a single LED source. Next, the emitted light will be detected by a sensor at the beginning of the receiver part. Finally, by processing the detected signal, the message will be displayed by using

some indicators. In addition, we assume that this system will be used in indoor because outside too much visible light may cause some malfunctions while the system is operating.

Description of Sub-Blocks

Here, we present our findings and solutions to some parts of the project as well as our guesses about the system.

1) Transmitter Block

We thought that our message may be 0 or 1, which is a set consisting of two elements. We chose a set with a small number of elements in order to make our work in the project simpler. To generate the electrical signals according to the messages, we decided to create sine waves. There are a few types of circuits that generate sine waves, which are Wien Bridge Oscillator and Phase Shift Oscillator. We decided that we may use Wien Bridge Oscillator to create sine waves since it is one of the most common ways to create sine wave and easy to construct its circuit. In Wien Bridge Oscillator circuit, we can adjust the frequency of the signal by changing the values of the resistors and capacitors. The formula for frequency in Wien Bridge Oscillator circuit is $f = 1/2\pi RC$ in general. We will use two sine wave generating circuits with two different frequencies, which represents two types of message. We will use ON-OFF switches to control the delivered messages in these sine generating circuits, so we can determine our message by using the switches. Alternatively, the electrical signals can be square waves, and creating two different square waves with different frequencies is another option for us. Next, we thought that we give the generated signal directly to the LED. The frequency that we choose should not disturb the human eye while the LED source is operating and transmitting the message; therefore, the frequencies should be chosen high as much as possible. In this case, we should also consider the amplitude of the signal as well as its frequency in order not to harm the LED that we use, so we should choose a single-color LED that has proper operating voltage range according to electrical signals. At the end of the transmitter part of the system, the LED source will create a visible light with a certain frequency. The LED will be ON and OFF according to the voltage across its terminals, which is due to the AC signals that we produced in signal creating circuits.

2) Receiver Block

In this block, at first, the emitted visible light will be detected by a sensor. We have alternatives for the sensor, which should be a photosensor (or photodetectors) in our opinion. There are many types of photosensors such as photoresistors (or LDR), photodiodes and phototransistors. We thought that photodiodes are more suitable for our system because they may pass the electric current when the light comes to them, and photodiodes are common in the market. We need photodiodes that operates in the visible light spectrum. A photodiode picture is shown in the Figure 2.

Figure 2: A photodiode

Since the LED source in the transmitter block gives light with a certain frequency by being ON and OFF mode, we may observe a signal with that same frequency in the terminals of the photodiode. The frequency of the observed signal in the receiver block can be used to distinguish the message about whether it is a 0 or 1. To determine the frequencies, we found that we can use filters. There are a few types of filters like active and passive filters. We decided to use an active bandpass filter to detect an exact signal with a certain frequency. In the active bandpass filter circuit, we can adjust the frequency range by changing the low and high cut-off frequency of the filter. By using two filter circuits, we may determine the message with the help of a LED indicator in each filter circuit. If a signal passes a filter, a LED indicator in that filter circuit will give light, and the other LED in the other filter circuit will not give light, so we can understand the message by looking at which LED in filter circuits is ON. Also, in this block, we may need AC to DC converter (or rectifier) circuits in after filter circuits to make the LEDs ON or OFF, which are indicator of the message in the receiver end.