LASER AUDIO COMMUNICATION SYSTEM

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DEDICATION

Dedicated to my family, especially Encik Abdul Rahman bin Mustafa, and Puan Sarimah binti Yusof. Also to my supervisor, Puan Zaiton binti Abdul Mutalip. Not to forget, to all my friends.

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ABSTRAK

Projek ini bertujuan untuk mereka dan membina komunikasi dua hala yang menggunakan laser sebagai perantaraan. Keistimewaan projek ini ialah dimana ia akan menghantar dan menerima isyarat audio secara serentak. Oleh itu, projek ini akan mencari penyelesaian untuk masalah tersebut dengan melakar dan membina system yang boleh menghantar dan menerima audio secara serentak. Sistem yang lengkap untuk projek ini akan mempunyai dua pasang penghantar dan dua pasang penerima. Konsepnya adalah merujuk kepada sistem komunikasi pendua penuh dimana akan menghantaran dan meneriman isyarat dalam masa yang sama.

ABSTRACT

The project is to design and built two ways communications system by using laser as an interface. The advantage of this project is it can transfer and receive audio simultaneously. Therefore, this project will find the solution for this problem by design and built the system that can transfer and receive audio simultaneously. The completed system for this project will consists of two transceivers, each capable of simultaneously transmitting and receiving audio signal. The concept is referring to full-duplex communication system where is use to transmit audio signal at the same time.

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CHAPTER 1

INTRODUCTION

Chapter one is focusing on the project introduction, project objectives problem statement, scope of work, report structure and the advantages of the project.

1.1 Project Introduction

A laser as a communications medium has some unique properties compared to other forms of media. A line-of-sight laser beam is useful where wires cannot be physically connected to a remote location. A laser beam, unlike wires, also does not require special shielding over longer distances. Lasers offer at least an order of magnitude longer distances compared to infrared LEDs. Although RF transmitters may offer longer distances than line-of-sight lasers, they are subject to interference from other transmitters. The main idea of this project is to transmit audio two ways by using the laser beam as an interface. This project will be use to transfer audio signal simultaneously. The completed system for this project will consist of two transmitters and two receivers each capable of simultaneously transmitting and receiving analogue signal.

The circuit board of this project has two sections where the first section is the transmitter unit and the second section is the receiver unit. Both of the unit is powered by a separate 9V battery. The transmitter board has an electrets microphone module at one end, and the laser diode at the other end. The electronics modulates the intensity of the laser beam according to the output of the microphone. The laser diode has a built-in collimating lens, and is simply a module that connects to the transmitter board.

The main function of the receiver part in this project is to get the signal from transmitter part. The circuit uses a photodiode as the receiving element; this project is to design with a high gain amplifier with a basic audio output stage.

1.2 Objectives

The main objective of this project is to design and built the prototype of two ways audio communication system by using laser as an interface. Then, the next objectives are to explore the application of laser in communication system. The last objective of this project is to investigate how laser can carry audio signal. It will include some theory and investigation that will be shown in this report.

1.3 Problem Statement

In general, there are so many type of communication in the world such as fiber optic. But fiber optic transmitters and receivers are still relatively expensive compared to laser. So, the laser system is the best choice available. Currently, there is only one way laser communications system that is capable of the transmission the audio available in the market. Unfortunately, by using one way communication system, it will create delays and not efficient. Therefore, this project is to find a solution for this problem by design and built the system that can transfer and receive audio in two ways simultaneously.

1.4 Scope of Work

The scope of this project is to design and built two way laser communications system where it can transmit and receive audio signal. The concept is similar to full-duplex communication system where is used to transmit and receive voice at the same time. For this project, a prototype of two ways audio communication system will be built with the distance of transmission is more than 10 meters. During the setting up link, the position of receiver must be right, so the laser beam falls on the solar cell. Once the link is established, adjust quiescent current with variable resistor. The function of variable resistor is to give a total current consumption of more than 45mA for the both side.

1.5 Report Structure

The report was divided into five chapters. The first chapter focusing on the introductions of the project. The introduction consists of the project brief introduction, objectives of the project, problem statement, scope of work and report structure.

The second chapter is about the literature review. This chapter is focusing on the documentation of the theory that related in designing the project. The review of previous case study is also included in this chapter.

The third chapter is mainly about the research methodology. All the progress and work flow are describe in this chapter.

The fourth chapter is about the project progress focusing on the result of the simulation. All the data that were obtained will be documented in this chapter. The full projects are shown.

The final chapter is focusing on the discussion and conclusion of this chapter. These included the entire result and its justification. Some suggestion on improving this project also will be discuss.

1.6 The advantages of the project

The advantage of the project is that users can communicate in two ways by using laser as an application. As well as people know, the world today is getting busy, therefore the people need try to find an alternative way to communicate with in the short distance. There are a lot of communication medium in this world such as walkie-talkie and telephone. Sometimes, it easy to break the code. So with this project, hopefully will be a solution of to this where users can save their privacy while communicating.

1.6.1 Save the health

This project is use laser as an interface. As well as people know it free from any dangerous frequency .Unlike the hand phone signal where it can give the bad affect for our health.

.2 Save the health

This project is use laser as an interface. As well as people know it free from any dangerous frequency .Unlike the hand phone signal where it can give the bad affect for our health.

3 Economical

Due to this device use the cheap laser and solar cells, users do not have to pay bill of telephone charge. So, it can save a lot of money.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews some references from previous project, journal, article, book, and data sheet. All these information was collected from the different sources such as library, internet, product manual, and etc.

2.1 Introduction to Laser

Lasers are devices that produce intense beams of light which are monochromatic, coherent, and highly collimated. The wavelength (color) of laser light is extremely pure (monochromatic) when compared to other sources of light, and all of the photons (energy) that make up the laser beam have a fixed phase relationship (coherence) with respect to one another. Light from a laser typically has very low divergence. It can travel over great distances or can be focused to a very small spot with a brightness which exceeds that of the sun. Because of these properties, lasers are used in a wide variety of applications in all walks of life. [1] [2] [12]

The term "laser" is an acronym for (L)ight (A)mplification by (S)timulated (E)mission of (R)adiation. To understand the laser, one needs to understand the meaning of these terms. The term "light" is generally accepted to be electromagnetic radiation ranging from 1 nm to 1000 mm in wavelength. The visible spectrum (what we see) ranges from approximately 400 to 700 nm. The wavelength range from 700 nm to 10 mm is considered the near infrared (NIR), and anything beyond that is the far infrared (FIR). Conversely, 200 to 400 nm is called ultraviolet (UV); below 200 nm is the deep ultraviolet (DUV). [1] [2]

2.1.1 The Bohr Atom

In 1915, Neils Bohr proposed a model of the atom that explained a wide variety of phenomena that were puzzling scientists in the late 19th century. This is simple model became the basis for the field of quantum mechanics and, although not fully accurate by today's understanding, still is useful for demonstrating laser principles. In Bohr's model as shown in figure 1, electrons orbit the nucleus of an atom. Unlike earlier "planetary" models, the Bohr atom has a limited number of fixed orbits that are available to the electrons.

Under the right circumstances an electron can go from its ground state (lowest-energy orbit) to a higher (excited) state, or it can decay from a higher state to a lower state, but it cannot remain between these states. The allowed energy states are called "quantum" states and are referred to by the principal "quantum numbers" 1, 2, 3, etc. The quantum states are represented by an energy-level diagram. For an electron to jump to a higher quantum state, the atom must receive energy from the outside world. This can happen through a variety of mechanisms such as inelastic or semielastic collisions with other atoms and absorption of energy in the form of electromagnetic radiation (e.g., light). Likewise, when an electron drops from a higher state to a lower state, the atom must give off energy, either as kinetic activity (nonradiative transitions) or as electromagnetic radiation (radiative transitions). [1][2]

2.1.2 Photon and Energy

In the 1600s and 1700s, early in the modern study of light, there was a great controversy about light's nature. Some thought that light was made up of particles, while others thought that it was made up of waves. Both concepts explained some of the behavior of light, but not all. It was finally determined that light is made up of particles called “photons” which exhibit both particle-like and wave-like properties. Each photon has an intrinsic energy determined by the equation. [1] [8]

$$E = h\nu \quad (2.1)$$

where is v the frequency of the light and *h* is Planck’s constant. Since, for a wave, the frequency and wavelength are related by the equation.

$$\lambda\nu = c \quad (2.2)$$

Where λ is the wavelength of the light and *c* is the speed of light in a vacuum, equation 2.1 can be rewritten as

$$E = \frac{hc}{\lambda} \quad (2.3)$$

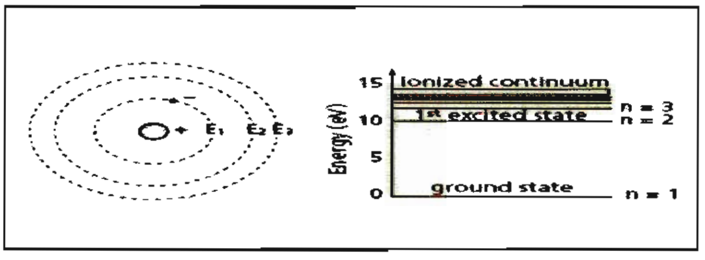

Figure 1: The Bohr atom and a simple energy-level Diagram [13]

It is evident from this equation that the longer the wavelength of the light, the lower the energy of the photon; consequently, ultraviolet light is much more “energetic” than infrared light. Returning to the Bohr atom: for an atom to absorb light (i.e., for the light energy to cause an electron to move from a lower energy state *E*n to a higher energy state *E*m), the energy of a single photon must equal, almost exactly, the energy difference between the two states. Too much energy or too little energy and the photon will not be absorbed. Consequently, the wavelength of that photon must be

$$\lambda = \frac{hc}{\Delta E}$$

Where (2.4)

$$\Delta E = E_m - E_n.$$

Likewise, when an electron decays to a lower energy level in radiative transition, the photon of light given off by the atom must also have energy equal to the energy difference between the two states. [1] [

2.1.3 Spontaneous and Stimulated Emission

In general, when an electron is in an excited energy state, it must eventually decay to a lower level, giving off a photon of radiation. This event is called "spontaneous emission," and the photon is emitted in a random direction and a random phase. The average time it takes for the electron to decay is called the time constant for spontaneous emission, and is represented by t. On the other hand, if an electron is in energy state $E2$, and its decay path is to $E1$, but, before it has a chance to spontaneously decay, a photon happens to pass by whose energy is approximately $E24E1$, there is a probability that the passing photon will cause the electron to decay in such a manner that a photon is emitted at exactly the same wavelength, in exactly the same direction, and with exactly the same phase as the passing photon. This process is called "stimulated emission." Absorption, spontaneous emission, and stimulated emission are illustrated in Figure 2.

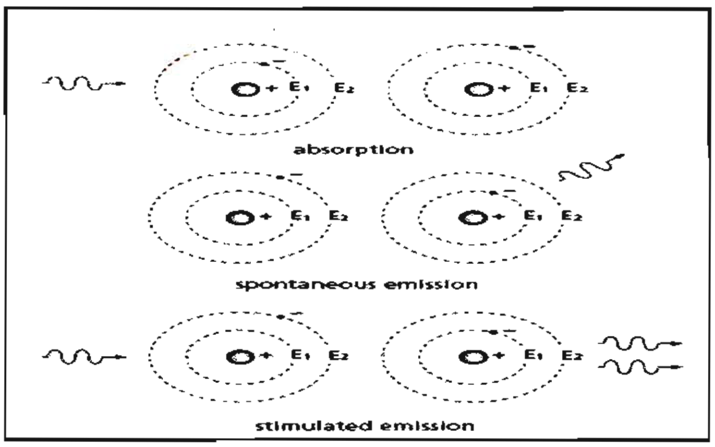

Figure 2: Spontaneous and stimulated emission [13]

Now consider the group of atoms shown in Figure 3, all begin in exactly the same excited state, and most are effectively within the stimulation range of a passing photon. We also will assume that t is very long, and that the probability for stimulated emission is 100 percent. The incoming (stimulating) photon interacts with the first atom, causing stimulated emission of a coherent photon, these two photons then interact with the next two atoms in line, and the result is four coherent photons, on down the line. At the end of the process, we will have eleven coherent photons, all with identical phases and all traveling in the same direction. In other words, the initial photon has been "amplified" by a factor of eleven. Note that the energy to put these atoms in excited states is provided externally by some energy source which is usually referred to as the "pump" source. [1] [2]

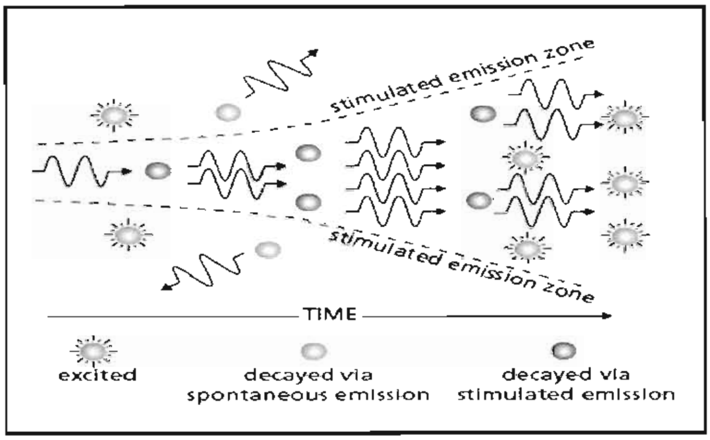

Figure 3 : Amplification by stimulated emission [13]

In any real population of atoms, the probability for stimulated emission is quite small. Furthermore, not all of the atoms are usually in an excited state; in fact, the opposite is true. Boltzmann's principle, a fundamental law of thermodynamics, states that, when a collection of atoms is at thermal equilibrium, the relative population of any two energy levels is given by

$$\frac{N_2}{N_1} = \exp\left(-\frac{E_2 - E_1}{kT}\right) \quad (2.5)$$

Where *N*2 and *N*1 are the populations of the upper and lower energy states, respectively, *T* is the equilibrium temperature, and *k* is Boltzmann's constant. Substituting *h*n for *E*24*E*1 yields

$$\Delta N \equiv N_1 - N_2 = \left(1 - e^{-h\nu/kT}\right)N_1. \quad (2.6)$$